CONTRA COSTA
COMMUNITY COLLEGE DISTRICT

LOS MEDANOS COLLEGE

Project Manual & Specifications

L-527

Mechanical Systems Upgrade

DSA Application #01-114479

DSA File #7-C1

SOBE Project #140094

SALAS O' BRIEN
SECTIONS 00007
SEALS PAGE AND DSA TESTS

ARCHITECT:

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ELECTRICAL ENGINEER:

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END OF SECTION 00007
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SECTION 22 07 19
PLUMBING PIPING INSULATION

PART 1 GENERAL
1.01 SECTION INCLUDES

1.02 REFERENCE STANDARDS

1.03 SUBMITTALS
   A. See Section 01 30 00 - Administrative 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 that ensure acceptable workmanship and installation standards will be achieved.

1.04 QUALITY ASSURANCE
   A. Manufacturer Qualifications: Company specializing in manufacturing the Products 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 three years of experience.

1.05 DELIVERY, STORAGE, AND HANDLING
   A. Accept materials on site, labeled with manufacturer's identification, product density, and thickness.

1.06 FIELD CONDITIONS
   A. Maintain ambient conditions required by manufacturers of each product.
   B. Maintain temperature before, during, and after installation for minimum of 24 hours.

PART 2 PRODUCTS
2.01 REQUIREMENTS FOR ALL PRODUCTS OF THIS SECTION
   A. Surface Burning Characteristics: Flame spread/Smoke developed index of 25/50, maximum, when tested in accordance with ASTM E84, NFPA 255, or UL 723.

PART 3 EXECUTION
3.01 EXAMINATION
   A. Verify that piping has been tested before applying insulation materials.
   B. Verify that surfaces are clean and dry, with foreign material removed.

3.02 INSTALLATION
   A. Install in accordance with manufacturer's instructions.

3.03 SCHEDULES

END OF SECTION
PART 1 GENERAL

1.01 SECTION INCLUDES
A. Pipe, pipe fittings, valves, and connections for piping systems.
1. Domestic water.

1.02 REFERENCE STANDARDS
A. ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings; The American Society of Mechanical Engineers; 2012 (ANSI B16.18).
B. ASME B16.22 - Wrought Copper and Copper Alloy Solder Joint Pressure Fittings; The American Society of Mechanical Engineers; 2013.
C. ASME B16.23 - Cast Copper Alloy Solder Joint Drainage Fittings - DWV; The American Society of Mechanical Engineers; 2011.
D. ASME B16.26 - Cast Copper Alloy Fittings for Flared Copper Tubes; The American Society of Mechanical Engineers; 2011.
E. ASME B31.9 - Building Services Piping; The American Society of Mechanical Engineers; 2011 (ANSI/ASME B31.9).
I. AWWA C651 - Disinfecting Water Mains; American Water Works Association; 2005 (ANSI/AWWA C651).

1.03 SUBMITTALS
A. See Division 1 for submittal procedures.
B. Product Data: Provide data on pipe materials, pipe fittings, valves, and accessories. Provide manufacturers catalog information. Indicate valve data and ratings.
C. Pipe Test Reports: Submit pipe pressure test reports for all piping installed under this contract indicating that piping systems have been tested in accordance with the California Plumbing Code.

1.04 QUALITY ASSURANCE
A. Perform work in accordance with applicable codes.
B. Valves: Manufacturer's name and pressure rating marked on valve body.
C. Identify pipe with marking including size, ASTM material classification, ASTM specification, potable water certification, water pressure rating.

1.05 REGULATORY REQUIREMENTS
A. Perform Work in accordance with State of California plumbing code.
B. All wetted parts of pipes, pipe and plumbing fittings, and fixtures for use in potable water systems shall be in compliance with California state bill AB1953, which served to amend California's Health and Safety Code 116875 (effective January 1, 2010). Lead content shall not exceed 0.25% by weight.
1.06 DELIVERY, STORAGE, AND HANDLING
A. Accept valves on site in shipping containers with labeling in place. Inspect for damage.
B. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.
C. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.

PART 2 PRODUCTS
2.01 WATER PIPING, ABOVE GRADE
A. Copper Tube: ASTM B88 (ASTM B88M), Type L (B), Drawn (H).
   1. Fittings: ASME B16.18, cast copper alloy or ASME B16.22, wrought copper and bronze.

2.02 FLANGES, UNIONS, AND COUPLINGS

PART 3 EXECUTION
3.01 PREPARATION
A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.
B. Remove scale and dirt, on inside and outside, before assembly.
C. Prepare piping connections to equipment with flanges or unions.

3.02 INSTALLATION
A. Install and test all plumbing piping systems in strict accordance with the California Plumbing Code.
B. Install in accordance with manufacturer's instructions.
C. Provide non-conducting dielectric connections wherever jointing dissimilar metals.
D. Route piping in orderly manner and maintain gradient. Route parallel and perpendicular to walls.
E. Install piping to maintain headroom, conserve space, and not interfere with use of space.
F. Group piping whenever practical at common elevations.
G. Provide clearance in hangers and from structure and other equipment for installation of insulation and access to valves and fittings. Refer to Section 22 07 19.
H. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welding.
I. Install water piping to ASME B31.9.
J. Sleeve pipe passing through roof.

3.03 DISINFECTION OF DOMESTIC WATER PIPING SYSTEM
A. Prior to starting work, verify system is complete, flushed and clean.
B. Ensure pH of water to be treated is between 7.4 and 7.6 by adding alkali (caustic soda or soda ash) or acid (hydrochloric).
C. Inject disinfectant, free chlorine in liquid, powder, tablet or gas form, throughout system to obtain 50 to 80 mg/L residual.
D. Bleed water from outlets to ensure distribution and test for disinfectant residual at minimum 15 percent of outlets.
E. Maintain disinfectant in system for 24 hours.
F. If final disinfectant residual tests less than 25 mg/L, repeat treatment.
G. Flush disinfectant from system until residual equal to that of incoming water or 1.0 mg/L.
H. Take samples no sooner than 24 hours after flushing, from 10 percent of outlets and from water entry, and analyze in accordance with AWWA C651.

END OF SECTION
PART 1 GENERAL

1.01 SECTION INCLUDES

A. Hose bibbs.

1.02 REFERENCE STANDARDS

A. ASSE 1011 - Hose Connection Vacuum Breakers; American Society of Sanitary Engineering; 2004 (ANSI/ASSE 1011).

1.03 SUBMITTALS

A. See Division 1 for Submittal Procedures.
B. Product Data: Provide component sizes, rough-in requirements, service sizes, and finishes.
C. Manufacturer's Instructions: Indicate Manufacturer's Installation Instructions: Indicate assembly and support requirements.
D. Maintenance Data: Include installation instructions, spare parts lists, exploded assembly views.

1.04 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with not less than three years documented experience.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Accept specialties on site in original factory packaging. Inspect for damage.

PART 2 PRODUCTS

2.01 HOSE BIBBS

A. Manufacturers:

B. Hose Bibbs:
   1. Bronze or brass with integral mounting flange, replaceable hexagonal disc, hose thread spout, chrome plated where exposed with handwheel, integral vacuum breaker in conformance with ASSE 1011.
   2. All wetted parts of pipe, valves, equipment and appurtenances for use in potable water systems shall be in compliance with the Reduction of Lead in Drinking Water Act, amendments to Section 1417 of the Safe Drinking Water Act which are effective January 4, 2014. Lead content shall not exceed 0.25% by weight.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer's instructions.

END OF SECTION
SECTION 23 05 19
METERS AND GAGES FOR HVAC PIPING

PART 1 GENERAL
1.01 SECTION INCLUDES
A. Pressure gages and pressure gage taps.
B. Thermometers and thermometer wells.

1.02 REFERENCE STANDARDS
A. ASME B40.100 - Pressure Gauges and Gauge Attachments; The American Society of Mechanical Engineers; 2005.

1.03 SUBMITTALS
A. See Division 1.
B. Product Data: Provide list that indicates use, operating range, total range and location for manufactured components. Indicate scale range, figure interval and minor graduation markings for all pressure and compound ranges.

1.04 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
2.01 PRESSURE GAGES
A. Manufacturers:
1. Ashcroft Model Duragage; Model 1279:
B. Gage: ASME B40.1, phenolic case, phosphor bronze bourdon tube, rotary geared brass movement, brass socket, with front recalibration adjustment, black scale on white background.
   1/2" NPT bottom system connection.
   1. Size: 4-1/2 inch diameter.
   2. Mid-Scale Accuracy: 1/2 percent.
   3. Scale: Psi.

2.02 PRESSURE GAGE TAPPINGS
A. Gage Cock: Tee or lever handle, brass for maximum 150 psi.

2.03 DIGITAL THERMOMETERS
A. Manufacturers:
   1. Size: 3-1/2 inch industrial stem
   2. Display: 3/8" LCD digits, wide ambient formula.
   3. Accuracy: 1 percent.
   4. Resolution: 1/10 Degrees F between -19.9/199.9 Degrees F
   5. Range: -40/300 Degrees F
   6. Ambient Operating Temperatures: -30/140 Degrees F
   7. Power: Integrated Photo Voltaic Cells

2.04 THERMOMETER SUPPORTS
A. Socket: Brass separable sockets for thermometer stems with or without extensions as required, and with cap and chain.
2.05 CONTROLS SUPPORTS
   A. Provide taps: Forged, ASTM A105 carbon steel, threaded branch connection suitable for sizes and schedules to be connected for 150 psig working pressure. Bonney Forge Thred-o-let or approved equal. Coordinate with Controls Subcontractor for size, location and quantities.

2.06 TEST PLUGS
   A. Test Plug: 1/4 inch or 1/2 inch brass fitting and cap for receiving 1/8 inch outside diameter pressure or temperature probe with neoprene core for temperatures up to 200 degrees F.

PART 3 EXECUTION
3.01 INSTALLATION
   A. Install in accordance with manufacturer's instructions.
   B. Provide one pressure gage per pump, installing taps before strainers and on suction and discharge of pump. Pipe to gage.
   C. Install thermometers in piping systems in sockets in short couplings. Enlarge pipes smaller than 2-1/2 inch for installation of thermometer sockets. Ensure sockets allow clearance from insulation.
   D. Install thermometer sockets adjacent to controls systems thermostat, transmitter, or sensor sockets.
   E. Provide instruments with scale ranges selected according to service with largest appropriate scale.
   F. Install gages and thermometers in locations where they are easily read from normal operating level. Install vertical to 45 degrees off vertical.
   G. Adjust gages and thermometers to final angle, clean windows and lenses, and calibrate to zero.
   H. Locate test plugs adjacent thermometers and thermometer sockets.

END OF SECTION
SECTION 23 05 53
IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 GENERAL

1.01 SECTION INCLUDES
A. Nameplates.
B. Tags.
C. Pipe Markers.

1.02 REFERENCE STANDARDS

1.03 SUBMITTALS
A. See Division 1 for submittal procedures.
B. List: Submit list of wording, symbols, letter size, and color coding for mechanical identification.
C. Product Data: Provide manufacturers catalog literature for each product required.

PART 2 PRODUCTS

2.01 IDENTIFICATION APPLICATIONS
A. Air Handling Units: Nameplates.
B. Reheat Coil: Tags.
C. Automatic Controls: Tags. Key to control schematic.
D. Control Panels: Nameplates.
E. Major Control Components: Nameplates.
F. Piping: Pipe markers.
G. Pumps: Nameplates.
H. Valves: Tags and ceiling tacks where located above lay-in ceiling.

2.02 NAMEPLATES
A. Manufacturers:
2. Kolbi Pipe Marker Co.: www.kolbi pipemarkers.com
4. Substitutions: See Division 1.
7. Background Color: Black.

2.03 TAGS
A. Manufacturers:
1. Advanced Graphic Engraving: www.advancedgraphicengraving.com
2. Brady Corporation: www.brady corp.com
5. Substitutions: See Division 1.

B. Plastic Tags: Laminated three-layer plastic with engraved black letters on light contrasting background color. Tag size minimum 1-1/2 inch diameter.
C. Metal Tags: Brass with stamped letters; tag size minimum 1-1/2 inch diameter with smooth edges.

2.04 PIPE MARKERS

A. Manufacturers:
   2. Kolbi Pipe Marker Co.: www.kolbipipemarkers.com
   5. Substitutions: See Division 1.

B. Color: Conform to ASME A13.1.

C. Plastic Pipe Markers: Factory fabricated, flexible, semi-rigid plastic, preformed to fit around pipe or pipe covering; minimum information indicating flow direction arrow and identification of fluid being conveyed.

D. Plastic Tape Pipe Markers: Flexible, vinyl film tape with pressure sensitive adhesive backing and printed markings.

PART 3 EXECUTION

3.01 PREPARATION

A. Degrease and clean surfaces to receive adhesive for identification materials.

3.02 INSTALLATION

A. Install nameplates with corrosive-resistant mechanical fasteners, or adhesive. Apply with sufficient adhesive to ensure permanent adhesion and seal with clear lacquer.

B. Install tags with corrosion resistant chain.

C. Install plastic pipe markers in accordance with manufacturer's instructions.

D. Install plastic tape pipe markers complete around pipe in accordance with manufacturer's instructions.

E. Use tags on piping 3/4 inch diameter and smaller.

F. For pipe markers, tape or tags:
   1. Identify service, flow direction, and pressure.
   2. Install in clear view and align with axis of piping.
   3. Locate identification not to exceed 20 feet on straight runs including risers and drops, adjacent to each valve and Tee, at each side of penetration of structure or enclosure, and at each obstruction.

END OF SECTION
SECTION 23 05 93
TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 GENERAL

1.01 SECTION INCLUDES
   A. Testing, adjustment, and balancing of air systems.
   B. Testing, adjustment, and balancing of heating hot water and chilled water systems.
   C. Measurement of final operating condition of HVAC systems.

1.02 REFERENCE STANDARDS

1.03 SUBMITTALS
   A. See Division 1 - Administrative Requirements, for submittal procedures
   B. Qualifications: Submit name of adjusting and balancing agency and TAB supervisor for approval within 30 days after award of Contract.
   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 Engineer.
      2. Include certification that the plan developer has reviewed the contract documents, the equipment and systems, and the control system with the Engineer and other installers to sufficiently understand the design intent for each system.
      3. 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. Identification and types of measurement instruments to be used and their most recent calibration date.
         d. Discussion of what notations and markings will be made on the duct and piping drawings during the process.
         e. Final test report forms to be used.
         f. 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.
         g. Expected problems and solutions, etc.
         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.
         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. Procedures for field technician logs of discrepancies, deficient or uncompleted work by others, contract interpretation requests and lists of completed tests (scope and frequency).

n. Procedures for formal deficiency reports, including scope, frequency and distribution.

D. 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.

E. Final Report: Indicate deficiencies in systems that would prevent proper testing, adjusting, and balancing of systems and equipment to achieve specified performance.

1. Revise TAB plan to reflect actual procedures and submit as part of final report.

2. Submit draft copies of report for review prior to final acceptance of Project. Provide final copies for Engineer and for inclusion in operating and maintenance manuals.

3. 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.

4. Include actual instrument list, with manufacturer name, serial number, and date of calibration.

5. Form of Test Reports: Where the TAB standard being followed recommends a report format use that; otherwise, follow ASHRAE Std 111.

6. Units of Measure: Report data in I-P (inch-pound) units only.

7. 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 Engineer.
   g. Project Contractor.
   h. Report date.

1.04 QUALITY ASSURANCE

A. Perform total system balance in accordance with AABC MN-1, ASHRAE Std 111, or NEBB Procedural Standards for Testing, Balancing and Adjusting of Environmental Systems.

B. TAB Agency Qualifications: Company specializing in the testing, adjusting, and balancing of systems specified in this Section with minimum three years documented experience certified by AABC.

C. Perform Work under supervision of AABC Certified Test and Balance Engineer or NEBB Certified Testing, Balancing and Adjusting Supervisor experienced in performance of this Work and licensed in California.

1.05 SEQUENCING AND SCHEDULING

A. Sequence work to commence after completion of systems and schedule completion of work before Substantial Completion of Project.

1.06 WARRANTY

A. Furnish AABC National Performance Guaranty for this project.
PART 2 PRODUCTS

2.01 GENERAL REQUIREMENTS

A. Test Instruments:
   1. Balancing Contractor shall provide all necessary test instruments required to take readings including, but not limited to: Pressure gauges, thermometers, humidity instruments, sling psychrometers, flow meter read out instruments (differential pressure gauges, etc.), air flow hoods, pitot tubes, anemometers, ammeters, voltmeters, tachometers, sound level meters, vibration analyzers, etc., as required to perform measurements required to perform the work of this section and applicable Commissioning specifications. These instruments are considered to be the property of the balancing contractor and required for usual performance of testing and balancing work. No allowance will be made for contractor's failure to provide adequate test instruments.

B. Incidental Equipment and Materials:
   1. Balancing Contractor shall provide at his own expense incidental and/or temporary equipment required to make such readings as required for the performance of this work. Such incidentals include but are not limited to: pipe nipples, couplings, tees, elbows, plugs and caps, gauge valves, teflon tape, and other miscellaneous fittings required to make readings required for balancing work. Incidentals and fittings shall be removed and the facility restored to 'as found' condition after completion of readings and balancing activities.

C. Tools and Labor:
   1. Balancing Contractor shall provide all tools and labor required to effect necessary readings for balancing work, including but not limited to: electric drill and bits, wrenches, pliers, screwdrivers, teflon tape, flashlights, rags, pocket knife or leatherman, pencils, pens, test forms, paper, and other minor tools required for work of this section.
   2. Provide labor to alter minor piping and other systems to allow temporary installation of test gages and thermometers, etc., required to make necessary readings. This includes removal of plugs on pump castings and temporary installation of piping, valves, gauges and nipples required to attach pressure gauges for readings, drilling required holes in ductwork and subsequent installation of plugs to allow ductwork pitot tube traverses, connections to flow elements, including a reasonable effort to clear obstructions from test ports, etc. Remove temporary fittings, valves and gauges at completion of readings and restore equipment to 'as found' condition.

PART 3 EXECUTION

3.01 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.
   4. 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.
   3. Certified by one of the following:

E. TAB Supervisor and Technician Qualifications: Certified by same organization as TAB agency.
F. Coordinate with controls contractor for work needed to complete test and balance work. Also see sequence of operation on controls sheet on plans for TAB work to be completed for the controls work.

3.02 EXAMINATION
A. Verify that systems are complete and operable before commencing work. Ensure the following conditions:
1. Systems are started and operating in a safe and normal condition.
2. Temperature control systems are installed complete and operable.
3. Proper thermal overload protection is in place for electrical equipment.
4. Final filters are clean and in place. If required, install temporary media in addition to final filters.
5. Duct systems are clean of debris.
6. Fans are rotating correctly.
7. Fire and volume dampers are in place and open.
8. Air coil fins are cleaned and combed.
9. Access doors are closed and duct end caps are in place.
10. Air outlets are installed and connected.
11. Duct system leakage is minimized.
12. Hydronic systems are flushed, filled, and vented.
13. Pumps are rotating correctly.
14. Proper strainer baskets are clean and in place.
15. Service and balance valves are open.
B. Submit field reports. Report defects and deficiencies that will or could prevent proper system balance.
C. Beginning of work means acceptance of existing conditions.

3.03 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. Required attendance by personnel that will actually be performing the balancing work.
B. Provide instruments required for testing, adjusting, and balancing operations. Make instruments available to Engineer to facilitate spot checks during testing.
C. Provide additional balancing devices as required.

3.04 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.

3.05 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. Mark on the drawings the locations where traverse and other critical measurements were taken and cross reference the location in the final report.

E. After adjustment, take measurements to verify balance has not been disrupted or that such disruption has been rectified.

F. Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, and restoring thermostats to specified settings.

G. At final inspection, recheck random selections of data recorded in report. Recheck points or areas as selected and witnessed by the District.

3.06 AIR SYSTEM PROCEDURE

A. After systems are balanced, work with the controls contractor to determine optimal final setpoint of fan system static pressure controls. Final setpoint shall be determined by supplying design airflow to all zones with one box throttling.

B. Adjust air handling and distribution systems to provide required or design supply, return, and exhaust air quantities at site altitude.

C. Make air quantity measurements in ducts by Pitot tube traverse of entire cross sectional area of duct.

D. Measure air quantities at air inlets and outlets.

E. Adjust distribution system to obtain uniform space temperatures free from objectionable drafts and noise.

F. 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.

G. Vary total system air quantities by adjustment of fan speeds. Provide drive changes required, including sheaves and labor. Vary branch air quantities by damper regulation.

H. Provide system schematic with required and actual air quantities recorded at each outlet or inlet.

I. 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.

J. Adjust outside air automatic dampers, outside air, return air, and exhaust dampers for design conditions.

K. Measure temperature conditions across outside air, return air, and exhaust dampers to check leakage.

L. 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.

M. 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.

N. See outside air setting per sequence of operations on drawings.

3.07 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.

3.08 SCOPE

A. Test, adjust, and balance the following:
   1. HVAC Pumps
   2. Air Coils
   3. Air Handling Units
   4. Air Inlets and Outlets

3.09 MINIMUM DATA TO BE REPORTED

A. Electric Motors:
   1. Manufacturer
   2. Model/Frame
   3. HP/BHP
   4. Phase, voltage, amperage; nameplate, actual, no load
   5. RPM
   6. Service factor
   7. Starter size, rating, heater elements
   8. Sheave Make/Size/Bore

B. V-Belt Drives:
   1. Identification/location
   2. Required driven RPM
   3. Driven sheave, diameter and RPM
   4. Belt, size and quantity
   5. Motor sheave diameter and RPM
   6. Center to center distance, maximum, minimum, and actual

C. 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

D. Cooling Coils:
   1. Identification/number
   2. Location
   3. Service
   4. Manufacturer
   5. Air flow, design and actual
   6. Entering air DB temperature, design and actual
7. Entering air WB temperature, design and actual
8. Leaving air DB temperature, design and actual
9. Leaving air WB temperature, design and actual
10. Water flow, design and actual
11. Water pressure drop, design and actual
12. Entering water temperature, design and actual
13. Leaving water temperature, design and actual
14. Saturated suction temperature, design and actual
15. Air pressure drop, design and actual

E. Heating Coils:
1. Identification/number
2. Location
3. Service
4. Manufacturer
5. Air flow, design and actual
6. Water flow, design and actual
7. Water pressure drop, design and actual
8. Entering water temperature, design and actual
9. Leaving water temperature, design and actual
10. Entering air temperature, design and actual
11. Leaving air temperature, design and actual
12. Air pressure drop, design and actual

F. Reheat Coils:
1. Identification/number
2. Location
3. Service
4. Manufacturer
5. Air flow, design and actual
6. Water flow, design and actual
7. Water pressure drop, design and actual
8. Entering water temperature, design and actual
9. Leaving water temperature, design and actual
10. Entering air temperature, design and actual
11. Leaving air temperature, design and actual
12. Air pressure drop, design and actual

G. Air Handling Unit:
1. Location
2. Manufacturer
3. Model number
4. Serial number
5. Arrangement/Class/Discharge
6. Air flow, specified and actual
7. Return air flow, specified and actual
8. Minimum outside air at low speed and high speed
9. Total static pressure (total external), specified and actual
10. Inlet pressure
11. Discharge pressure
12. Sheave Make/Size/Bore
13. Number of Belts/Make/Size
14. Fan RPM

H. Air Distribution Tests:
1. Air terminal number
2. Room number/location
3. Terminal type
4. Terminal size
5. Area factor
6. Design velocity
7. Design air flow
8. Test (final) velocity
9. Test (final) air flow
10. Percent of design air flow

END OF SECTION
PART 1 GENERAL

1.01 SUMMARY

A. Ductwork Insulation

1.02 QUALITY ASSURANCE

A. Qualification of Workers: Use proficient journeyman insulators and supervisors in the execution of this portion of the work to ensure proper and adequate installation of insulation throughout. A firm with at least 5 years successful installation experience on projects with installations similar to that required for this project.

B. Compliance with Specifications:
1. Whenever required during progress of the work, furnish proof acceptable to the District that items installed are equal to or exceed requirements specified for this work.
2. In the event such proof is not available, or is not acceptable to the District, the District may require the Contractor to remove the item or items and replace with material meeting the specified requirements and to repair damage caused in the removal and replacement, at no additional cost to the District.
3. Install per manufacturer’s written instructions.
4. As a minimum, comply with appropriate state energy code or other applicable codes.
5. Duct insulation products to contain less than 0.1 percent by weight PBDE in all insulating materials.

1.03 SUBMITTALS

A. Product Data: Submit manufacturer’s technical data and installation instructions for each type of insulation, jacket, glue, paint, fitting cover, and accessory. Submit schedule showing manufacturer’s product number, thickness, and furnished accessories for duct system requiring insulation.

1.04 PRODUCT HANDLING

A. Protection: Use all means necessary to protect insulation materials before, during and after installation.

B. Replacements: In the event of damage, immediately make repairs and replacements necessary.

1.05 LINING MATERIALS

A. Materials to be mold-, humidity-, and erosion-resistant surface that meets the requirements of UL 181.

1.06 FIRE HAZARD CLASSIFICATION

A. Maximum fire hazard classification of the composite insulation construction as installed to be not more than a flame spread of 25, fuel contributed of 50 and smoke developed of 50 as tested by ASTM E84 (NFPA 255) method.

B. Test duct insulation in accordance with ASTM E84 and bear the UL label.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Armacell LLC Armaflex, Certainteed, Johns Mansville, Knauf, Owens-Corning, PPG, or approved.

2.02 TYPE A, FLEXIBLE FIBERGLASS BLANKET

A. ASTM C553, Type 1, Class B-2; flexible blanket.

B. 'K' Value: 0.27 BTU•in/(hr•sf•F) at 75 degrees F installed, maximum service temperature: 250 degrees F.
C. Density: 0.75 pounds per cubic foot.
D. Vapor Barrier Jacket: FSK aluminum foil reinforced with fiberglass yarn and laminated to fire resistant Kraft, secured with UL listed pressure sensitive tape or outward clinched expanded staples and vapor barrier mastic as needed.

2.03 TYPE B, DUCT LINER
A. ASTM C1071; flexible blanket.
B. 'K' Value: ASTM C518, 0.25 BTU*in/(hr*sf*F) at 75 degrees F, maximum service temperature: 250 degrees F.
C. Noise Reduction Coefficient: 0.65 or higher based on "Type A mounting."
D. Maximum Velocity on Mat or Coated Air Side: 5,000 FPM.
E. Adhesive: UL listed waterproof type.
F. Fasteners: Duct liner galvanized steel pins. Welded or mechanically fastened.
G. Erosion-Resistant Services: UL 181.
H. ASTM G21 and ASTM G22 Microbial Growth Resistance.

2.04 OUTDOOR DUCTING
A. Aluminum Jacket: 0.016-inch-thick sheet, smooth/embossed finish, with longitudinal slip joints and 2-inch laps.
B. Nonwater vapor retarder, nonburning, weatherproof coating for use over insulation where "breathing" is required.
C. UV resistant polyvinyl chloride covering with joints secured and sealed.

2.05 JACKETING
B. Canvas Jacket: UL listed fabric, 6 oz/sq.yd., plain weave cotton treated with dilute fire retardant lagging adhesive.
C. Aluminum Jacket: 0.016-inch-thick sheet, (smooth/embossed) finished, with longitudinal slip joints and 2-inch laps, die-shaped fitting covers with factory attached protective liner.
D. Stainless Steel Jacket: Type 304 stainless steel, 0.010 inch, (smooth/corrugated) finish.

PART 3 EXECUTION
3.01 VERIFICATION OF CONDITIONS
A. Do not apply insulation until pressure testing of the ducts has been completed. Do not apply insulation until the duct has been inspected.
B. Examine areas and conditions under which duct insulation will be installed. Do not proceed with work until unsatisfactory conditions have been corrected.

3.02 PREPARATION
A. Clean and dry surface to be insulated.

3.03 INSTALLATION
A. Install insulation in conformance with the manufacturer's recommendations to completely cover the duct.
B. Butt insulation joints firmly together and install jackets and tapes smoothly and securely.
C. Apply duct insulation continuously through sleeves and prepared openings, except as otherwise specified. Apply vapor barrier materials to form a complete unbroken vapor seal over the insulation.
D. Coat staples and seals with vapor barrier coating.
E. Cover breaks in the jacket material with patches of the same material as the vapor barrier. Extend the patches not less than 2 inches beyond the break or penetration in all directions and secure with adhesive and staples. Seal staples and joints with brush coat of vapor barrier coating.

F. Fill jacket penetrations, i.e., hangers, thermometers and damper operating rods, and other voids in the insulation with vapor barrier coating. Seal the penetration with a brush coat of vapor barrier coating.

G. Seal and flash insulation terminations and pin punctures with a reinforced vapor barrier coating.

H. Duct Liners: Install mat finish surface on air stream side. Secure insulation to cleaned sheet metal duct with a continuous 100 percent coat of adhesive. For widths over 20 inches, additionally secure the liner with mechanical fasteners 15 inches on center. Accurately cut liner and thoroughly coat ends with adhesive. Butt joints tightly. Top and bottom sections of insulation overlap sides. Keep duct liner clean and free from dust. At completion of project, vacuum duct liner if it is dirty or dusty. Do not use small pieces. If insulation is installed without horizontal, longitudinal, and end joints butted together, installation will be rejected and work removed and replaced with work that conforms to this Specification.

I. Duct Wrap: Cover supply air ducts except ducts internally lined. Wrap tightly with circumferential joints butted and longitudinal joints overlapped minimum of 2 inches. Adhere insulation with 4-inch strips of insulating bending adhesive at 8 inches on center. On ducts over 24 inches wide, additionally secure insulation with suitable mechanical fasteners at 18 inches on center. Circumferential and longitudinal joints stapled with flare staples 6 inches on center and covered with 3-inch-wide, foil reinforced tape.

3.04 PROTECTION AND REPLACEMENT

A. Protect installed insulation during construction. Replace damaged insulation which cannot be repaired satisfactorily, including units with vapor barrier damage and moisture saturated units.

3.05 DUCTWORK SURFACES TO BE INSULATED

<table>
<thead>
<tr>
<th>ITEM TO BE INSULATED:</th>
<th>SYSTEM INSULATION TYPE:</th>
<th>DUCT SIZE:</th>
<th>INSULATION THICKNESS:</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUPPLY DUCTWORK (WHERE DUCT IS NOT SPECIFIED TO BE LINED).</td>
<td>A</td>
<td>ALL</td>
<td>1”</td>
</tr>
<tr>
<td>SUPPLY AND RETURN DUCTWORK (EXPOSED TO WEATHER, IN CRAWL SPACE, AND IN UNHEATED ATTICS).</td>
<td>A</td>
<td>ALL</td>
<td>2”</td>
</tr>
<tr>
<td>HVAC PLENUMS AND UNIT HOUSINGS NOT PREINSULATED.</td>
<td>B</td>
<td>ALL</td>
<td>2”</td>
</tr>
</tbody>
</table>

A. NOTE: INSULATION THICKNESS SHOWN IN A MINIMUM. DUCTWORK EXPOSED TO WEATHER, CRAWL SPACES, OR UNHEATED ATTICS SHALL BE INSULATED TO A MINIMUM INSTALLED LEVEL OF R-8. ALL OTHER PORTIONS OF DUCTWORK SHALL BE INSULATED TO A MINIMUM INSTALLED LEVEL OF R-4.2 PER THE 2013 BUILDING ENERGY EFFICIENCY STANDARDS, TITLE 24.
SECTION 23 07 19
HVAC PIPING AND EQUIPMENT INSULATION

PART 1 GENERAL

1.01 SUMMARY
A. Piping and Equipment Insulation: Materials and installation of insulation, jackets and accessories for the following applications:
B. Cold domestic water piping systems.
C. Chilled water piping systems.
D. Heating water piping systems.
E. Hot and cold surfaces of mechanical equipment.

1.02 QUALITY ASSURANCE
A. Qualification of Workers: Use proficient journeyman insulators and supervisors in the execution of this portion of the work to ensure proper and adequate installation of insulation throughout. A firm with at least 5 years successful installation experience on projects with installations similar to that required for this project.
B. Compliance with Specifications:
1. Whenever required during progress of the work, furnish proof acceptable to the District that items installed are equal to or exceed requirements specified for this work.
2. In the event such proof is not available, or is not acceptable to the District, the District may require the Contractor to remove the item or items and replace with material meeting the specified requirements and to repair damage caused in the removal and replacement, at no additional cost to the District.
3. Install per manufacturer's written instructions.
4. As a minimum, comply with appropriate state energy code or other applicable codes.
5. Piping insulation products to contain less than 0.1 percent by weight PBDE in all insulating materials.

1.03 SUBMITTALS
A. Product Data: Submit manufacturer's technical data and installation instructions for each type of insulation, jacket, glue, paint, fitting cover, and accessory. Submit schedule showing manufacturer's product number, thickness, and furnished accessories for each pipe and equipment requiring insulation.

1.04 PRODUCT HANDLING
A. Protection: Use all means necessary to protect insulation materials before, during and after installation.
B. Replacements: In the event of damage, immediately make repairs and replacements necessary.

1.05 FIRE HAZARD CLASSIFICATION
A. Maximum fire hazard classification of the composite insulation construction as installed to be not more than flame spread of 25, fuel contributed of 50 and smoke developed of 50 as tested by ASTM E84 (NFPA 255) method.
B. Test pipe insulation in accordance with the requirements of UL "Pipe and Equipment Coverings R5583 400 8.15."

PART 2 PRODUCTS

2.01 MANUFACTURERS
A. Armacell LLC Armaflex, Certainteed, Imcoa, Johns Mansville, Knauf, Nomaco, Owens-Corning, PPG or approved.
2.02 TYPE 1, FIBERGLASS PIPE INSULATION

A. Glass Fiber: ASTM C547; rigid molded, noncombustible.
   1. Thermal Conductivity Value: 0.27 at 75°F.
   2. Maximum Service Temperature: 850°F.
   3. Vapor Retarder Jacket: White Kraft paper reinforced with glass fiber and bonded to aluminum foil, secure with self-sealing longitudinal laps and butt strips or AP Jacket with outward clinch expanding staples or vapor barrier mastic as needed.

2.03 TYPE 2, FLEXIBLE ELASTOMERIC INSULATION

A. Elastomeric Foam: ASTM C534; flexible, cellular elastomeric, molded or sheet.
B. Thermal Conductivity Value: 0.25 BTU\textperinch}^2/(\text{hr}\cdot\text{sf}\cdot\text{F}) at 75 degrees F.
C. Maximum Service Temperature of 220 degrees F.
D. Maximum Flame Spread: 25.
E. Maximum Smoke Developed: 50 (1-inch thick and below).
F. Connection: Waterproof vapor retarder adhesive as needed.
G. UV Protection: UV outdoor protective coating per manufacturers requirements.
H. Glue: Contact adhesive specifically manufactured for cementing flexible elastomeric foam. Armacell LLC Armaflex, Halstead, or approved equivalent.
I. Paint: Nonhardening high elasticity type, specifically manufactured as protective covering of flexible elastomeric foam insulation for prevention of degradation due to exposure to sunlight and weather. Armacell LLC Armaflex, Halstead, or approved equivalent.

2.04 TYPE 4, CELLULAR GLASS

A. Cellular Glass Insulation: Foamglass pipe insulation fabricated in accordance with ASTM C552 and C585. Thermal conductivity of 0.33 BTU\textperinch}^2/(\text{hr}\cdot\text{sf}\cdot\text{F}) at 50 degrees F.

2.05 ACCESSORIES

A. Equipment Insulation Jacketing: Presized glass cloth, not less than 7.8 ounces/sq.yd., except as otherwise indicated. Coat with gypsum based cement.
B. Equipment Insulation Compounds: Provide adhesives, cement, sealers, mastics, and protective finishes as recommended by insulation manufacturer for applications indicated.
C. General: Provide staples, bands, wire, wire netting, tape corner angles, anchors, stud pins and metal covers as recommended by insulation manufacturer for applications indicated. Accessories, i.e., adhesives, mastics, cements and tape to have the same flame and smoke component ratings as the insulation materials with which they are used. Shipping cartons to bear a label indicating that flame and smoke ratings do not exceed those listed above. Provided permanent treatment of jackets or facings to impart flame and smoke safely. Provided nonwater soluble treatments.

2.06 PIPE FITTING INSULATION COVERS

A. PVC preformed molded insulation covers. Zeston, or approved.

2.07 CANVAS JACKET

A. UL listed fabric, 6 ounces/sq.yd./plain weave cotton treated with dilute fire retardant lagging adhesive.

2.08 JACKETING

B. Canvas Jacket: UL listed fabric, 6 oz/sq.yd., plain weave cotton treated with dilute fire retardant lagging adhesive.
C. Aluminum Jacket: 0.016-inch-thick sheet, (smooth/embossed) finish, with longitudinal slip joints and 2-inch laps, die shaped fitting covers with factory attached protective liner.

D. Stainless Steel Jacket: Type 304 stainless steel, 0.010 inch, (smooth/corrugated) finish.

PART 3 EXECUTION

3.01 PREPARATION

A. Clean and dry surfaces to be insulated.

3.02 INSTALLATION

A. Piping and Equipment:

B. Install insulation over clean, dry surfaces with adjoining sections firmly butted together and covering surfaces. Fill voids and holes. Seal raw edges. Install insulation in a manner such that the insulation may be split, removed, and reinstalled with vapor barrier tape on strainer caps and unions. Do not install insulation until the piping has been leak tested and has passed such tests. Do not insulate chiller manholes, equipment manufacturer's nameplates, handholes, and ASME stamps. Provide beveled edge at such insulation interruptions. Repair voids or tears.

C. Cover insulation on pipes above ground, outside of buildings, with aluminum jacketing. Position seam on bottom of pipe.

3.03 PROTECTION AND REPLACEMENT

A. Protect installed insulation during construction. Replace damaged insulation which cannot be repaired satisfactorily, including units with vapor barrier damage and moisture saturated units.

3.04 FIBERGLASS INSULATION

A. Lap seal insulation with waterproof adhesive. Do not use staples or other methods of attachment which would penetrate the vapor barrier. Apply fitting covers with seated tacks and vapor barrier tape.

B. Apply insulation to pipe and seal with self-sealing lap. Use self-sealing butt strips to seal butt joints. Insulate fittings, valves and unions with single or multiple layers of insulation and cover to match pipe or use preformed PVC molded insulation covers.

3.05 LABELING AND MARKING

A. Provide labels, arrows and color coding on piping. Attach labels and arrows to the jacketing.

3.06 PIPING SURFACES TO BE INSULATED

<table>
<thead>
<tr>
<th>ITEM TO BE INSULATED</th>
<th>SYSTEM INSULATION TYPE:</th>
<th>PIPE SIZE:</th>
<th>INSULATION THICKNESS:</th>
</tr>
</thead>
<tbody>
<tr>
<td>DOMESTIC COLD WATER</td>
<td>1</td>
<td>&lt;=&lt;2”</td>
<td>1/2”</td>
</tr>
<tr>
<td>ABOVEGROUND HEATING PIPING</td>
<td>1, 4</td>
<td>RUNOUTS UP TO 2” ALL OTHERS</td>
<td>1”</td>
</tr>
<tr>
<td>ABOVEGROUND CHILLED WATER PIPING</td>
<td>1, 4</td>
<td>RUNOUTS UP TO 2” ALL OTHERS</td>
<td>1”</td>
</tr>
<tr>
<td>ABOVEGROUND CHILLED, HEATING, EXPOSED TO WEATHER</td>
<td>1, 4</td>
<td>2-1/4” TO 6”</td>
<td>2”</td>
</tr>
</tbody>
</table>

A. NOTE: INSULATION THICKNESS SHOWN IN A MINIMUM. IF STATE CODES REQUIRE ADDITIONAL THICKNESS, THEN PROVIDE INSULATION THICKNESS PER CODE REQUIREMENTS.
3.07 INSULATED PIPE EXPOSED TO WEATHER

A. Where piping is exposed on roof, cover insulation with aluminum jacket. Seal watertight jacket per manufacturer’s recommendations. Provide heat tracing on piping subject to freezing.

END OF SECTION
SECTION 23 09 15
BUILDING AUTOMATION SYSTEM

PART 1 - GENERAL

1.01 WORK INCLUDED:

A. Related Documents: The General Provisions of the Contract, including General,
Supplementary, and Special Conditions, and Division 1 - General Requirements, apply to work
specified in this section. Subcontractor must familiarize himself with the terms of the above
documents.

B. BAS Contractor
1. The Building Automation System (BAS) is to be furnished and installed by a factory
authorized Andover distributor with factory warranted Andover parts.
   a. All bidders must be building automation contractors in the business of installing
      Director Digital Controls (DDC) for a minimum of 3 years.
   b. All bidders must have an office in the San Francisco Bay/Central Valley area.
   c. All bidders must be an authorized distributor or branch office for "Andover Controls".
   d. All bidders must have a trained staff of application engineers, who have been certified
      by Andover in Administration, Networking, Configuration, Programming and service of
      the automation system.
   e. All installers must have a factory-trained technician on-site at all times during
      installation of the DDC controls.
2. Integration of the BAS system to the College's central BAS system shall be coordinated
   with the Facilities Manager at the work site.

C. Scope of Work
1. The BAS contractor shall review and study all HVAC drawings and the entire specification
to familiarize himself with the equipment and system operation and to verify the quantities
and types of dampers, operators, alarms, etc. to be provided.
2. The Contractor shall furnish and install all necessary hardware and all operating and
applications software necessary to perform the control sequences of operation and points
list as shown on the drawings. Interface all equipment with existing control system and
update graphics.
3. Provide services and manpower necessary for commissioning of system in coordination
with the HVAC Contractor, Balancing Contractor and Districts representative.
4. All work performed under this section of the specifications will comply with all codes, laws
and governing bodies. If the drawings and/or specifications are in conflict with governing
codes, the Contractor shall submit a proposal with appropriate modifications to the project
to meet code restrictions. If this specification and associated drawings exceed governing
code requirements, the specification will govern.

D. Training: Provide a minimum of (10) hours of on-site training for (3) system operators. The
training will be hands-on type at the owner's office. The training class will use the actual
Operator's Manual that will be submitted for this project. In addition to: projects over $100,000
will include (2) weeks of classroom training for one individual at the Manufacturer's sponsored
training courses.

E. System Description
1. The Building Automation System (BAS) shall consist of PC-based workstation (existing)
and microcomputer controllers of modular design providing distributed processing
capability, and allowing future expansion of both input/output points and
processing/control functions.
   a. For this project the system shall consist of the following (new) components:
      1) Ethernet-based Network Controller.
      2) Stand-alone Digital Control Units.
F. Ethernet-based Network Controller: The BAS Contractor shall furnish Ethernet-based network controller. This controller will connect directly to the campus LAN over the existing Ethernet system. BXC1 (as required) and shall be assigned to an existing Infinet Loop.

G. Provide the necessary quantity and types of SDCUs to meet the requirements of the project for mechanical equipment control including air handlers, return/exhaust fans, and terminal unit control. Each SDCU will operate completely standalone, containing all of the I/O and programs to control its associated equipment; i2920-D, i2800 series and Infinet II.

H. Work by Others
   1. The BAS Contractor shall cooperate with other contractors performing work on this project necessary to achieve a complete and neat installation. To that end, each contractor shall consult the drawings and specifications for all trades to determine the nature and extent of others' work.
   2. The BAS Contractor shall furnish all control valves, sensor wells, flow meters and other similar equipment for installation by the Mechanical Contractor. The Electrical Contractor shall provide:
      a. Transformer Model Number - Andover ZFTR50VA002.

I. Code Compliance
   1. All wiring shall conform to the National Electrical Code.
   2. All smoke dampers shall be rated in accordance with UL 555S.
   3. Comply with FCC rules, Part 15 regarding Class A radiation for computing devices and low power communication equipment operating in commercial environments.

J. Submittals
   1. All shop drawings shall be prepared in Visio Professional or AutoCAD software. In addition to the drawings, the Contractor shall furnish a diskette containing the identical information. Drawings shall be B size or larger.
   2. Shop drawings shall include a riser diagram depicting locations of all controllers and workstations, with associated network wiring. Also included shall be individual schematics of each mechanical system showing all connected points with reference to their associated controller. Typical drawings shall be provided where appropriate.
   3. Submittal data shall contain manufacturer's data on all hardware and software products required by the specification. Valve, damper and air flow station schedules shall indicate size, configuration, capacity and location of all equipment.
   4. Software submittals shall contain narrative descriptions of sequences of operation, program listings, point lists, and a complete description of the graphics, reports, alarms and configuration to be furnished with the workstation software. Information shall be bound or in a three ring binder with an index and tabs.
   5. Submit five (5) copies of submittal data and shop drawings to the Engineer and (one) copy to Facilities for review prior to ordering or fabrication of the equipment. The Contractor prior to submitting shall check all documents for accuracy.
   6. The Engineer will make corrections, if required, and forward to Facilities prior to returning to the Contractor. The Contractor will then resubmit with the corrected or additional data. This procedure shall be repeated until all corrections are made to the satisfaction of the Engineer and the submittals are fully approved.

K. System Startup & Commissioning
   1. Each point in the system shall be tested for both hardware and software functionality. In addition, each mechanical and electrical system under control of the BAS will be tested against the appropriate sequence of operation specified herein. Successful completion of the system test shall constitute the beginning of the warranty period. A written report will be submitted to the owner indicating that the installed system functions in accordance with the plans and specifications.
   2. The BAS contractor shall commission and set in operating condition all major equipment and systems, such as the chilled water, hot water and all air handling systems, in the...
presence of the equipment manufacturer's representatives, as applicable, and the District's and Architect's representatives.

3. The BAS Contractor shall provide all manpower and engineering services required to assist the HVAC Contractor and Balancing Contractor in testing, adjusting, and balancing all systems in the building. The BAS Contractor shall have a trained technician available on request during the balancing of the systems. The BAS Contractor shall coordinate all requirements to provide a complete air balance with the Balancing Contractor and shall include all labor and materials in his contract.

L. Training
1. The BAS Contractor shall provide both on-site and classroom training to the District's representative and maintenance personnel per the following description:
   a. System Overview
   b. System Software and Operation
   c. System access
   d. Software features overview
   e. Changing setpoints and other attributes
   f. Scheduling
   g. Editing programmed variables
   h. Displaying color graphics
   i. Running reports
   j. Workstation maintenance
   k. Application programming
   l. Operational sequences including start-up, shutdown, adjusting and balancing.
   m. Equipment maintenance.

M. Operating and Maintenance Manuals
1. The operation and maintenance manuals shall contain all information necessary for the operation, maintenance, replacement, installation, and parts procurement for the entire BAS. This documentation shall include specific part numbers and software versions and dates. A complete list of recommended spare parts shall be included with the leadtime and expected frequency of use of each part clearly identified.
2. Following project completion and testing, the BAS contractor will submit as-built drawings reflecting the exact installation of the system. The as-built documentation shall also include a copy of all application software both in written form and on diskette.

N. Warranty: The BAS contractor shall warrant the system for 12 months after system acceptance and beneficial use by the owner. During the warranty period, the BAS contractor shall be responsible for all necessary revisions to the software as required to provide a complete and workable system consistent with drawings Sequence of Operation and points list.

PART 2 - PRODUCTS
2.01 SYSTEM ARCHITECTURE
A. General
1. The Building Automation System (BAS) shall consist of Network Control Units (NCUs), a family of Standalone Digital Control Units (SDCUs), Input/Output Unit Modules (IOU Modules), Operator Workstations (OWs), and one File Server to support system configurations where more than one operator workstation is required. The BAS shall provide control, alarm detection, scheduling, reporting and information management for the entire facility, and Wide Area Network (WAN) if applicable, from a single ODBC-compliant database.

B. Level 1 Network Description: Level 1, the main backbone of the system, shall be an Ethernet LAN/WAN. Network Control Units, Operator Workstations, and the Central File Server shall connect directly to this network without the need for Gateway devices.

Contra Costa Community College District
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BUILDING AUTOMATION SYSTEM

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C. Level 2 Network Description

1. Level 2 of the system shall consist of one or more field buses managed by the Network Control Units. The Level 2 field buses may consist of one or both of the following types:
   a. An RS485, token passing bus that supports up to 127 Standalone Digital Control Units (SDCUs) for operation of HVAC equipment and lighting, or
   b. An RS485 field bus that supports up to 32 devices from a family of plug-in, IOU modules.
2. These IOU modules may be mounted within the NCU enclosure or remotely mounted via a single, twisted, shielded pair of wires.

D. BAS: The BAS shall be capable of being segmented, through software, into multiple local area networks (LANs) distributed over a wide area network (WAN), sharing a single file server. This enables workstations to manage a single LAN (or building), and/or the entire system with all devices being assured of being updated by and sharing the most current database. In the case of a single workstation system, the workstation shall contain the entire database – with no need for a separate file server.

E. Standard Network Support: All NCUs, Workstation(s) and File Server shall be capable of residing directly on the owner's Ethernet TCP/IP LAN/WAN with no required gateways. Furthermore, the NCU's, Workstation(s) and File Server shall be capable of using standard, commercially available, off-the-shelf Ethernet infrastructure components such as routers, switches and hubs. With this design the owner may utilize the investment of an existing or new enterprise network or structured cabling system. This also allows the option of the maintenance of the LAN/WAN to be performed by the owner's Information Systems Department as all devices utilize standard TCP/IP components.

F. System Expansion

1. The BAS system shall be scalable and expandable at all levels of the system using the same software interface, and the same Level 1 and Level 2 controllers. Systems that require replacement of either the workstation software or field controllers in order to expand the system shall not be acceptable.
2. The BAS shall be expandable to include Security and Access Control functions at any time in the future with no additional workstations, front-end software or Level 1 controllers required. Standalone Digital Control Units or IOU modules shall be able to be added to the existing Level 1 controller's field bus(es), to perform security and card access applications. In this way, an owner's existing investment in wiring infrastructure may be leveraged and the cost and inconvenience of adding new field bus wiring will be minimized.
3. Additionally, an integrated video badging option must be able to be included with no additional workstations required. This photo ID option must share the same database as the BAS in order to eliminate the need for updating multiple databases.
4. The system shall use the same application programming language for all levels: Operator Workstation, Network Control Unit, Remote Site Control Unit and Standalone Digital Control Unit. Furthermore, this single programming language shall be used for all applications: environmental control, card access control, intrusion detection and security, lighting control, leak detection / underground storage tank monitoring, and digital data communication interfaces to third party microprocessor-based devices.

G. Support For Open Systems Protocols

1. The BAS design must include solutions for the integration of the following "open systems" protocols: BACnet, LonTalkO, and digital data communication to third party microprocessors such as chiller controllers, fire panels and variable frequency drives (VFDs).
2. The system shall also provide the ability to program custom ASCII communication drivers, that will reside in the NCU, for communication to third party systems and devices. These drivers will provide real time monitoring and control of the third party systems.

2.02 NETWORK CONTROL UNITS (NCUS)

A. General

Contra Costa Community College District
Los Medanos College
L-527 Mechanical Systems Upgrade
1. Network Control Units shall be microprocessor based, multi-tasking, multi-user, and employ a real time operating system. Each NCU control panel shall consist of modular hardware including power supply, CPU board, and input/output modules. A sufficient number of NCUs shall be supplied to fully meet the requirements of this specification and the attached point list.

2. NCUs for telephone dialup sites shall be of the same design as the Ethernet control units but without the plug-in Ethernet network interface card (NIC), i.e., NCUs, which include a NIC, shall be interchangeable whether used on a LAN/WAN or a dialup site.

B. Websserver Functionality

1. All NCUs on the Ethernet TCP/IP LAN/WAN shall be capable, out-of-the-box, to be set up as a Web Server. The NCU shall have the ability to store HTML code and "serve" pages to a web browser. This provides the ability for any computing device utilizing a TCP/IP Ethernet connection and capable of running a standard Internet browser (Microsoft Internet Explorer® or Netscape Navigator®) to access real-time data from the entire BAS via any NCUs.

2. Graphics and text-based web pages shall be constructed using standard HTML code. The interface shall allow the user to choose any of the standard text or graphics-based HTML editors for page creation. It shall also allow the operator to generate custom graphical pages and forms.

3. The WEB server interface shall be capable of password security, including validation of the requesting PC's IP address. The WEB server interface shall allow the sharing of data or information between any controller, or process or network interface (BACnet, LonTalk and TCP/IP) that the BAS has knowledge of, regardless of where the point is connected on the BAS network or where it is acquired from.

4. The BAS network controller must act directly as the WEB server. It must directly generate the HTML code to the requesting user (i.e., WEB browser), eliminating the need for and reliance on any PC-based WEB server hardware or software. To simplify graphic image space allocation, HTML graphic images, if desired, shall be stored on any shared network device. The BAS WEB server shall have the ability to acquire any necessary graphics using standard pathing syntax within the HTML code mounted within the BAS WEB server. External WEB server hardware and software are not acceptable.

C. Hardware Specifications

1. Memory:
   a. A minimum of 4MB of RAM shall be provided for NCUs with expansion up to 8MB. The 8MB versions shall include a floating-point math co-processor.

D. Communication Ports: Each NCU shall provide communication to both the Workstation(s) and the field buses. In addition, each NCU must have at least 3 other communications ports that support a telephone modem, portable service tool, serial printer and connection to third party controllers such as a chiller control panel. On a LAN/WAN system the NCU shall be provided with a 10Mbps plug-in Ethernet TCP/IP network interface card (NIC).

E. Input/Output (I/O):

1. Each NCU shall support the addition of the following types of inputs and outputs:
   a. Digital Inputs for status/alarm contacts
   b. Counter inputs for summing pulses from meters.
   c. Thermistor inputs for measuring temperatures in space, ducts and thermowells.
   d. Analog inputs for pressure, humidity, flow and position measurements.
   e. Digital Outputs for on/off equipment control.
   f. Analog Outputs for valve and damper position control, and capacity control of primary equipment.

F. Modular Expandability: The system shall employ a modular I/O design to allow easy expansion. Input and output capacity is to be provided through plug-in modules of various types or DIN-mountable IOU modules. It shall be possible to combine I/O modules as desired to meet the I/O requirements for individual control applications.
G. Real Time Clock (RTC): Each NCU shall include a battery-backed, real time clock, accurate to 10 seconds per day. The RTC shall provide the following: time of day, day, month, year, and day of week. In normal operation the system clock will be based on the frequency of the AC power. The system shall automatically correct for daylight savings time and leap years and be Year 2000 compliant.

H. Power Supply: The power supply for the NCUs shall be auto sensing, 120-220VAC, 60/50 Hz power, with a tolerance of +/- 20%. Line voltage below the operating range of the system shall be considered outages. The controller shall contain over voltage surge protection, and require no additional AC power signal conditioning. Optionally, if indicated on the drawings, the power supply shall accept an input voltage of (-48 VDC).

I. Automatic Restart After Power Failure: Upon restoration of power after an outage, the ECU shall automatically and without human intervention: update all monitored functions; resume operation based on current, synchronized time and status, and implement special start-up strategies as required.

J. Battery backup: Each NCU with the standard 120-220VAC power supply shall include a programmable DC power backup system rated for a minimum of 72 hours of battery backup to maintain all volatile memory or, a minimum of 2 hours of full UPS including modem power. This power backup system shall be configurable such that at the end of a settable timeframe (such as 1 hour) of running on full UPS, the unit will shut off full UPS and switch to memory retention-only mode for the remainder of the battery power. The system shall allow the simple addition of more batteries to extend the above minimum battery backup times.

K. Software Specifications: User Programming Language: The application software shall be user programmable. This includes all strategies, sequences of operation, control algorithms, parameters, and setpoints. The source program shall be English language-based and programmable by the user. The language shall be constructed to allow for the easy configuration of control programs, schedules, alarms, reports, telecommunications, local displays, mathematical calculations, passwords, and histories. The language shall be self-documenting. Users shall be able to place comments anywhere in the body of a program. Program listings shall be configurable by the user in logical groupings.

L. Control Software:
   1. The NCU shall have the ability to perform the following pre-tested control algorithms:
      a. Proportional, Integral plus Derivative Control (PID)
      b. Self Tuning PID
      c. Two Position Control
      d. Digital Filter
      e. Ratio Calculator

M. Mathematical Functions: Each controller shall be capable of performing basic mathematical functions (+, - , *, /), squares, square roots, exponential, logarithms, Boolean logic statements, or combinations of both. The controllers shall be capable of performing complex logical statements including operators such as >, <, =, and, or, exclusive or, etc. These must be able to be used in the same equations with the mathematical operators and nested up to five parentheses deep.

N. Energy Management Applications:
   1. NCUs shall have the ability to perform any or all of the following energy management routines:
      a. Time of Day Scheduling
      b. Calendar Based Scheduling
      c. Holiday Scheduling
      d. Temporary Schedule Overrides
      e. Optimal Start
      f. Optimal Stop
      g. Night Setback Control
      h. Enthalpy Switchover (Economizer)
O. History Logging: Each controller shall be capable of logging any system variable over user defined time intervals ranging from 1 second to 1440 minutes. Any system variables (inputs, outputs, math calculations, flags, etc.) can be logged in history. A maximum of 32767 values can be stored in each log. Each log can record either the instantaneous, average, minimum or maximum value of the point. Logs can be automatic or manual. Logged data shall be downloadable to the Operator Workstation for long term archiving based upon user-defined time intervals, or manual command

P. Alarm Management: For each system point, alarms can be created based on high/low limits or conditional expressions. All alarms will be tested each scan of the NCU and can result in the display of one or more alarm messages or reports

Q. Up to 8 alarms can be configured for each point in the controller.

R. Messages and reports can be sent to a local terminal, to the front-end workstation(s), or via modem to a remote-computing device.

S. Alarms will be generated based on their priority. A minimum of 255 priority levels shall be provided. If communication with the Operator Workstation is temporarily interrupted, the alarm will be buffered in the NCU. When communications return, the alarm will be transmitted to the Operator Workstation if the point is still in the alarm condition

T. Reporting: The NCU shall be able to generate user-definable reports to a locally connected printer or terminal. The reports shall contain any combination of text and system variables. Report templates shall be able to be created by users in a word processing environment. Reports can be displayed based on any logical condition or through a user command

2.03 STANDALONE DIGITAL CONTROL UNITS (SDCUS)

A. General: Standalone Digital Control Units shall provide control of HVAC and lighting. Each controller shall have its own control programs and will continue to operate in the event of a failure or communication loss to its associated NCU

B. Memory: Control programs shall be stored in battery backed-up RAM and EPROM. Each controller shall have a minimum of 32K bytes of user RAM memory and 128K bytes of EPROM

C. Communication Ports: SDCUs shall provide a communication port to the field bus. In addition, a port shall be provided for connection of a portable service tool to support local commissioning and parameter changes with or without the NCU online. It shall be possible from a service port on any SDCU to view, enable/disable, and modify values of any point or program on any controller on the local field bus, any NCU or any SDCU on a different field bus

D. Input/Output:
   1. Each SDCU shall support the addition of the following types of inputs and outputs:
      a. Digital Inputs for status/alarm contacts
      b. Counter Inputs for summing pulses from meters.
      c. Thermistor Inputs for measuring temperatures in space, ducts and thermowells.
      d. Analog inputs for pressure, humidity, flow and position measurements.
      e. Digital Outputs for on/off equipment control.
      f. Analog Outputs for valve and damper position control, and capacity control of primary equipment.
E. Expandability: Input and output capacity shall be expandable through the use of plug-in modules. A minimum of two modules shall be added to the base SDCU before additional power is required.

F. Networking: Each SDCU will be able to exchange information on a peer to peer basis with other Standalone Digital Control Units during each field bus scan. Each SDCU shall be capable of storing and referencing global variables (on the LAN) with or without any workstations online. Each SDCU shall be able to have its program viewed and/or enabled/disabled either locally through a portable service tool or through a workstation connected to an NCU.

G. Indicator Lamps: SDCUs will have as a minimum, LED indication of CPU status, and field bus status.

H. Real Time Clock (RTC): An SDCU shall have a real time clock in either hardware or software. The accuracy shall be within 10 seconds per day. The RTC shall provide the following information: time of day, day, month, year, and day of week. Each SDCU shall receive a signal, every hour, over the network from the NCU which synchronizes all SDCU real time clocks.

I. Automatic Restart After Power Failure: Upon restoration of power, the SDCU shall automatically and without human intervention, update all monitored functions, resume operation based on current, synchronized time and status, and implement special start-up strategies as required.

J. Battery Back Up: Each SDCU shall have at least 3 years of battery back up to maintain all volatile memory.

K. Alarm Management:
   1. For each system point, alarms can be created based on high/low limits or conditional expressions. All alarms will be tested each scan of the SDCU and can result in the display of one or more alarm messages or reports.  
   2. Up to 8 alarms can be configured for each point in the controller enabling the escalation of the alarm priority (urgency) based upon which alarm(s) is/are triggered.  
   3. Alarm messages can be sent to a local terminal or modem connected to an NCU or to the Operator's Workstation(s).  
   4. Alarms will be generated based on their priority. A minimum of 255 priority levels shall be provided.  
   5. If communication with the NCU is temporarily interrupted, the alarm will be buffered in the SDCU. When communications return, the alarm will be transmitted to the NCU if the point is still in the alarm condition.

L. Air Handler Controllers (To be used on units with less than 40 points)
   1. AHU Controllers shall be capable of meeting the requirements of the sequence of operation found in the Execution portion of this specification and for future expansion.  
   2. AHU Controllers shall support all the necessary point inputs and outputs as required by the sequence and operate in a standalone fashion.  
   3. AHU Controllers shall be fully user programmable to allow for modification of the application software.  
   4. An LCD display shall be optionally available for readout of point values and to allow operators to change setpoints and system parameters.  
   5. A manual override switch shall be provided for all digital and analog outputs on the AHU Controller. The position of the switch shall be monitored in software and available for operator displays and alarm notification.

M. Display Controllers
   1. Display controllers are standalone, touch screen based operator interfaces. The controller shall be designed for flush mounting in a finished space, with a minimum display size of 9 x 9 inches.  
   2. Software shall be user programmable allowing for custom graphical images that simulate floor plans, menus, equipment schematics along with associated real time point values coming from any NCU on the network.
3. The touch screen display shall contain a minimum of 64 possible touch cells that permit user interaction for changing screens, modifying setpoints or operating equipment.

4. Systems that do not offer a display controller as specified must provide a panel mounted computer with touch screen capability as an alternative.

2.04 OPERATOR WORKSTATION REQUIREMENTS (EXISTING LAN SYSTEM) WORKSTATION AND SERVER ARE NOT ADDED TO THIS PROJECT. HOWEVER ALL CONTROLLERS WILL BE ADDED TO THE EXISTING INFINET AND LAN SYSTEM.

A. Temperature Sensors
   1. All temperature devices shall use precision thermistors accurate to +/- 1 degree F over a range of -30 to 230 degrees F. Space temperature sensors shall be accurate to +/- .5 degrees F over a range of 40 to 100 degrees F.
      a. Duct Sensors - Andover Model Number: TT-D-9-1
      b. Well Sensors - Andover Model Number: TT-I-6-1
   2. Duct temperature sensors shall incorporate a thermistor bead embedded at the tip of a stainless steel tube. Probe style duct sensors are useable in air handling applications where the coil or duct area is less than 14 square feet.
   3. Averaging sensors shall be employed in ducts, which are larger than 14 square feet. The averaging sensor tube must contain at least one thermistor for every 3 feet, with a minimum tube length of 12 feet.
   4. Immersion sensors shall be employed for measurement of temperature in all chilled and hot water applications as well as refrigerant applications. Thermal wells shall be brass or stainless steel for non-corrosive fluids below 250 degrees F and 300 series stainless steel for all other applications.
   5. A pneumatic signal shall not be allowed for sensing temperature.

B. Current and KW Sensors
   1. Current status switches shall be used to monitor fans, pumps, motors and electrical loads. Current switches shall be available in solid and split core models, and offer either a digital or an analog signal to the automation system. Acceptable manufacturer is Veris or approved equal.
   2. Measurement of three phase power shall be accomplished with a kW/kWH transducer. This device shall utilize direct current transformer inputs to calculate the instantaneous value (kW) and a pulsed output proportional to the energy usage (kWH). Provide Veris Model 6000 Power Transducer or approved equal.

C. Electric/Pneumatic Transducers
   1. Electric to pneumatic transducers shall operate from either a PWM or analog signal. E/P transducers shall be rated for 0 - 20 psi operation and accurate to 2% of full scale. E/P transducers shall have a maximum air consumption of 100 SCIM.
   2. E/P transducers may be installed at the end device (damper or valve), or mounted separately in a field interface panel, or as part of the controller. All transducers will be calibrated. Panel mounted transducers shall be Modus or approved equal.

D. Electric/Pneumatic Solenoid Valves
   1. Electric solenoid operated pneumatic valves (EP's) shall have a three port operation: common, normally open and normally closed. They shall be rated for 50 psig when used for 25 psig or less applications, or rated for 150 psig when used for 100 psig or less applications. The coils shall be equipped with transient suppression devices to limit transients to 150 percent of the rated coil voltage.

2.05 CONTROL VALVES

A. Provide automatic control valves suitable for the specified controlled media (Hot and Chilled Water). Provide valves, which mate and match the material of the connected piping. Equip control valves with the actuators of required input power type and control signal type to accurately position the flow control element and provide sufficient force to achieve required leakage specification. Provide control valves as specified on schedule on drawings.
B. Contractor to size valve Cv so that differential pressure at rated flow is between 3 to 5 psig. Valves requiring less than 0.7 gpm to be provided with a Cv = 0.4.

C. Control valves shall meet the heating and cooling loads specified, and close off against the differential pressure conditions within the application. Valves should be sized to operate accurately and with stability from 10 to 100% of the maximum design flow.

D. Electric actuation should be provided on all terminal unit reheat applications.

E. 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 actuator shall have electronic overload circuitry to prevent damage. For power-failure/safety applications, an internal mechanical, spring return mechanism shall be built into the actuator housing. Non-spring return actuators shall have an external manual gear release to allow positioning of the damper when the actuator is not powered.

2.06 SMOKE DETECTORS

A. Smoke Detector - Siemens Model Number: FP-11.

2.07 AIRFLOW MEASURING STATIONS

A. Provide a thermal anemometer using instrument grade self heated thermistor sensors with thermistor temperature sensors.

B. The flow station shall operate over a range of 0 to 5,000 feet/min with an accuracy of +/- 2% over 500 feet/min and +/- 10 ft/min for reading less than 500 feet/min.

C. The output signal shall be linear with field selectable ranges including 0-5 VDC, 0-10VDC and 4-20 mA.

D. Furnish Ebtron Gold Series airflow stations or approved equal.

PART 3 – EXECUTION

3.01 CONTRACTOR RESPONSIBILITIES

A. General: The BAS system is to be furnished and installed by an Andover approved Contractor. The Contractor shall certify all work as proper and complete. Under no circumstances shall the design; scheduling, coordination, programming, training, and warranty requirements for the project are delegated to a subcontractor.

B. Access to Site: Unless notified otherwise, entrance to building is restricted. No one will be permitted to enter the building unless their names have been cleared with the District or the District’s Representative.

C. Code Compliance: All wiring shall be installed in accordance with all applicable electrical codes and will comply with equipment manufacturer’s recommendations.

D. Cleanup: At the completion of the work, all equipment pertinent to this contract shall be checked and thoroughly cleaned, and all other areas shall be cleaned around equipment provided under this contract. Clean the exposed surfaces of tubing, hangers, and other exposed metal of grease, plaster, or other foreign materials.

3.02 WIRING, CONDUIT, AND CABLE

A. All wire will be copper and meet the minimum wire size and insulation class listed below:

B. Power and Class One wiring may be run in the same conduit. Class Two and Three wiring and communications wiring may be run in the same conduit.

C. Where different wiring classes terminate within the same enclosure, maintain clearances and install barriers per the National Electric Code.

D. Where wiring is required to be installed in conduit, EMT shall be used. Conduit shall be minimum 1/2 inch galvanized EMT. Set screw fittings are acceptable for dry interior locations. Watertight compression fittings shall be used for exterior locations and interior locations subject to moisture. Provide conduit sealoff fitting where exterior conduits enter the building or between areas of high temperature/moisture differential.
E. Flexible metallic conduit (max. 3 feet) shall be used for connections to motors, actuators, controllers, and sensors mounted on vibration producing equipment. Liquid-tight flexible conduit shall be use in exterior locations and interior locations subject to moisture.

F. Junction boxes shall be provided at all cable splices, equipment termination, and transitions from EMT to flexible conduit. Interior dry location J-boxes shall be galvanized pressed steel, nominal four-inch square with blank cover. Exterior and damp location JH-boxes shall be cast alloy FS boxes with threaded hubs and gasketed covers.

G. Pneumatic tubing will be FR rated polyethylene instrumentation tubing, type M, hard copper tubing, or soft copper tubing. All pneumatic tubing will be sized for a maximum pressure drop of 2 PSI from the pressure-reducing valve to end device.

H. Coaxial cable shall conform to RG62 or RG59 rating. Provide plenum rated coaxial cable when running in return air plenums.

I. Fiber optic cable shall include the following sizes; 50/125, 62.5/125 or 100/140: Only glass fiber is acceptable, no plastic.

J. Fiber optic cable shall only be installed and terminated by an experienced contractor. The BAS contractor shall submit to the Engineer the name of the intended contractor of the fiber optic cable with his submittal documents.

3.03 HARDWARE INSTALLATION
A. Installation Practices for Wiring
1. All controllers are to be mounted vertically and per the manufacturer's installation documentation.
2. A true earth ground must be available in the building. Do not use a corroded or galvanized pipe, or structural steel.
3. Conduit in finished areas, will be concealed in ceiling cavity spaces, plenums, furred spaces and wall construction. Exception; metallic surface raceway may be used in finished areas on masonry walls. All surface raceway in finished areas must be color matched to the existing finish within the limitations of standard manufactured colors.
4. Conduit, in non-finished areas where possible, will be concealed in ceiling cavity spaces, plenums, furred spaces, and wall construction. Exposed conduit will run parallel to or at right angles to the building structure.
5. Wires are to be kept a minimum of three (3) inches from hot water, steam, or condensate piping.
6. Where sensor wires leave the conduit system, they are to be protected by a plastic insert.
7. Wire or pneumatic tubing will not be allowed to run across telephone equipment areas.
8. All wiring running down exposed walls to controls or control panels shall be run in EMT or completely enclosed in metal raceways.
9. All control wiring in concrete walls or floors shall run in rigid conduit.

B. Installation Practices for Field Devices
1. Well-mounted sensors will include thermal conducting compound within the well to insure good heat transfer to the sensor.
2. Actuators will be firmly mounted to give positive movement and linkage will be adjusted to give smooth continuous movement throughout 100 percent of the stroke.
3. Relay outputs will include transient suppression across all coils. Suppression devices shall limit transients to 150% of the rated coil voltage.
4. Water line mounted sensors shall be removable without shutting down the system in which they are installed.
5. For duct static pressure sensors, the high pressure port shall be connected to a metal static pressure probe inserted into the duct pointing upstream. The low pressure port shall be left open to the plenum area at the point that the high pressure port is tapped into the ductwork.
6. For building static pressure sensors, the high pressure port shall be inserted into the space via a metal tube. Pipe the low pressure port to the outside of the building.
C. Enclosures
1. For all I/O requiring field interface devices, these devices where practical will be mounted in a field interface panel (FIP). The Contractor shall provide an enclosure which protects the device(s) from dust, moisture, conceals integral wiring and moving parts.
2. FIPs shall contain power supplies for sensors, interface relays and contactors, safety circuits, and I/P transducers.
3. The FIP enclosure shall be of steel construction with baked enamel finish, NEMA 1 rated with a hinged door and keyed lock. The enclosure will be sized for twenty percent spare mounting space. All locks will be keyed identically.
4. All wiring to and from the FIP will be to screw type terminals. Analog or communications wiring may use the FIP as a raceway without terminating. The use of wire nuts within the FIP is prohibited.
5. All outside mounted enclosures shall meet the NEMA-4 rating.
6. The wiring within all enclosures shall be run in plastic track. Wiring within controllers shall be wrapped and secured.

D. Identification
1. Identify all control wires with labeling tape or sleeves using either words, letters, or numbers that can be exactly cross-referenced with as-built drawings.
2. Identify all pneumatic tubing with labeling tape or sleeves using words, letters, or numbers that can be exactly cross-referenced with as-built drawings.
3. All field enclosures, other than controllers, shall be identified with a bakelite nameplate. The lettering shall be in white against a black or blue background.
4. Junction box covers will be marked to indicate that they are a part of the BAS system.
5. All I/O field devices (except space sensors) that are not mounted within FIP’s shall be identified with name plates.
6. All I/O field devices inside FIP’s shall be labeled.

E. Location
1. The location of sensors is per mechanical and architectural drawings.
2. Space humidity or temperature sensors will be mounted away from machinery generating heat, direct light and diffuser air streams.
3. Outdoor air sensors will be mounted on the north building face directly in the outside air. Install these sensors such that the effects of heat radiated from the building or sunlight is minimized.
4. Field enclosures shall be located immediately adjacent to the controller panel(s) to which it is being interfaced.

3.04 SOFTWARE INSTALLATION
A. General: The software design and implementation is to be facilitated only by an Andover approved Contractor. The Contractor shall provide all labor necessary to install, initialize, startup and debug all system software as described in this section. This includes any operating system software or other third party software necessary for successful operation of the system.
B. Database Configuration: The Contractor will provide all labor to configure those portions of the database that are required by the points list and sequence of operation.
C. Color Graphic Slides:
1. Unless otherwise directed by the owner, the Contractor will provide color graphic displays matching the Campus Standards for each system and floor plan.
2. For each system or floor plan, the display shall contain the associated points identified in the point list and allow for setpoint changes as required by the owner.
   a. Animations and 3D Rendering.
   b. Animations to mimic all moving devised, status and operation.
   c. Animations set to maximum performance, compatible with Version 1.81.
   d. Individual slides; mechanical equipment, VAV/CAV boxes, pumps, motors, fans, dampers, thermostats, and valves.
D. Reports.
   1. The Contractor will configure a minimum of 6 reports for the District as listed below:
      a. Air Handler Status Report
      b. Space Temperature Report
      c. Specialty Equipment Status Report

E. Documentation
   1. As built software documentation will include the following:
      a. Descriptive point lists
      b. Application program listing
      c. Application programs with comments.
      d. Printouts of all reports.
      e. Alarm list.
      f. Printouts of all graphics

3.05 COMMISSIONING AND SYSTEM STARTUP

A. Point to Point Checkout: Each I/O device (both field mounted as well as those located in FIPs) shall be inspected and verified for proper installation and functionality. A checkout sheet itemizing each device shall be filled out, dated and approved by the Facilities Manager for submission to the Owner's representative.

B. Controller Checkout: A field checkout of all controllers shall be conducted to verify proper operation of both hardware and software. A checkout sheet itemizing each device and a description of the associated tests shall be prepared and submitted to the Owner or Owner's representative by the completion of the project.

C. System Acceptance Testing
   1. All application software will be verified and compared against the sequences of operation. Control loops will be exercised by inducing a setpoint shift of at least 10% and observing whether the system successfully returns the process variable to setpoint. Record all test results and attach to the Test Results Sheet.
   2. Test each alarm in the system and validate that the system generates the appropriate alarm message, that the message appears at all prescribed destinations (workstations or printers), and that any other related actions occur as defined (i.e. graphic panels are invoked, reports are generated, etc.). Submit a Test Results Sheet to the District.
   3. Perform an operational test of each unique graphic display and report to verify that the item exists, that the appearance and content are correct, and that any special features work as intended. Submit a Test Results Sheet to the District.
   4. Perform an operational test of each third party interface that has been included as part of the automation system. Verify that all points are properly polled, that alarms have been configured, and that any associated graphics and reports have been completed. If the interface involves a file transfer over Ethernet, test any logic that controls the transmission of the file, and verify the content of the specified information.

3.06 SEQUENCES OF OPERATION

A. See Drawings.

END OF SECTION
PART 1 GENERAL

1.01 SECTION INCLUDES

A. Heating water piping, above grade.
B. Chilled water piping, above grade.
C. Valves:
   1. Ball valves.
   2. Butterfly valves.
   3. Check valves.

1.02 REFERENCE STANDARDS

A. ASME (BPV IX) - Boiler and Pressure Vessel Code, Section IX - Welding and Brazing Qualifications; The American Society of Mechanical Engineers; 2013.
B. ASME B16.3 - Malleable Iron Threaded Fittings; The American Society of Mechanical Engineers; 1998 (R2006).
D. ASME B16.22 - Wrought Copper and Copper Alloy Solder Joint Pressure Fittings; 2013.
E. ASME B31.9 - Building Services Piping; 2011 (ANSI/ASME B31.9).
K. AWS A5.8/A5.8M - Specification for Filler Metals for Brazing and Braze Welding; 2011 and errata.

1.03 SUBMITTALS

A. See Division 1 for submittal procedures.
B. Shop Drawings: Submit complete shop drawings for piping system showing all fittings, elevations, pipe accessories, hanger locations and all connected equipment. Submit on reproducible velum, and compact disk. Drawings shall be produced in AutoCad 2008 or later release.
C. Product Data: Include data on pipe materials, pipe fittings, valves, and accessories. Provide manufacturers catalogue information. Indicate valve data and ratings.
D. Welders Certificate: Include welders certification of compliance with ASME (BPV IX).
E. Manufacturer's Installation Instructions: indicate hanging and support methods, joining procedures.
F. As-Built Drawings: At project closeout, provide as-built drawings of the piping systems installed. Drawings shall be prepared using AutoCad 2008 or later release. Submit two reproducible copies and two complete sets of drawing files on a compact disc.

1.04 QUALITY ASSURANCE
A. Manufacturer Qualifications: Company specializing in manufacturing products of the type specified in this section, with minimum three years of documented experience.
B. Installer Qualifications: Company specializing in performing work of the type specified in this section, with minimum three years of experience.
C. Provide all grooved joint couplings, fittings, valves, specialties, and grooving tools from a single manufacturer.
D. Welder Qualifications: Certify in accordance with ASME (BPV IX).
   1. Provide certificate of compliance from authority having jurisdiction, indicating approval of welders.

1.05 DELIVERY, STORAGE, AND HANDLING
A. Accept valves on site in shipping containers with labeling in place. Inspect for damage.
B. Provide temporary protective coating on cast iron and steel valves.
C. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.
D. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.

PART 2 PRODUCTS
2.01 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.
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.

2.02 HEATING WATER PIPING, ABOVE GROUND
A. Steel Pipe: ASTM A53/A53M, Schedule 40, black, using one of the following joint types:
   4. Joints: Threaded, or AWS D1.1 welded.

2.03 CHILLED WATER PIPING, ABOVE GRADE
A. Steel Pipe Sizes 10" and under: ASTM A 53, Grade A or B, electric resistance welded or seamless, Schedule 40, black.
   1. Fittings: ASME B16.3, malleable iron threaded or ASTM A 234/A 234M, forged steel welding type, or 150 lb factory fabricated grooved.
   2. Joints: Threaded (2" and under), Grooved, Victaulic Style 07 - Zero Flex, no known equal, Flanged or Welded.
2.04 PIPE HANGERS AND SUPPORTS

A. Provide hangers and supports that comply with MSS SP-58.
   1. If type of hanger or support for a particular situation is not indicated, select appropriate
type using MSS SP-58 recommendations.

B. Wall Support for Pipe Sizes to 3 Inches: Cast iron hook.

C. Wall Support for Pipe Sizes 4 Inches and Over: Welded steel bracket and wrought steel clamp.

D. Vertical Support: Steel riser clamp.

E. Inserts: Malleable iron case of galvanized steel shell and expander plug for threaded
   connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms; size
   inserts to suit threaded hanger rods.

F. Rooftop supports: see drawings.

2.05 UNIONS, FLANGES, MECHANICAL COUPLINGS, AND DIELECTRIC CONNECTIONS

A. Unions for Pipe 2 Inches and Under:
   1. Ferrous Piping: 150 psig malleable iron, threaded.
   2. Copper Pipe: Bronze, soldered joints.

B. Flanges for Pipe Over 2 Inches:
   1. Ferrous Piping: 150 psig forged steel, slip-on.
   2. Copper Piping: Bronze.
   3. Gaskets: 1/16 inch thick preformed neoprene.

C. Dielectric Connections: Waterway with electro zinc plated casing, chemically inert, non
corrosive, self-cleaning NSF/FDA listed dielectric thermoplastic waterway. Thermoplastic liner
shall meet requirements of ASTM Standard F-492. Threaded ends. Victaulic, ClearFlow, or
approved equal.

2.06 BALL VALVES

A. Manufacturers:

B. Up To and Including 2 Inches:
   1. Bronze two piece body, stainless steel ball, teflon seats and stuffing box ring, lever
      handle, threaded ends.

C. Over 2 inches:
   1. Cast steel body, chrome plated steel ball, teflon seat and stuffing box seals, lever handle,
      flanged.

2.07 BUTTERFLY VALVES

A. Manufacturers:
   1. Tyco Flow Control: www.tycoflowcontrol.com
   3. Centerline Series 200

B. Body: ANSI Class 150, Cast or ductile iron with resilient replaceable EPDM seat, lug ends,
   extended neck where required for insulation.

C. Shaft: Stainless steel, one piece through disc design
D. Disc (for general duty): Aluminum bronze.
E. Manual Operators: 10 position lever handle up through 4", above 4", provide gear operator and handwheel. Where mounted higher than 7' above floor, provide chain wheel and chain to 3' above floor.

2.08 SWING CHECK VALVES
A. Manufacturers:
4. Substitutions: See Division 1.
B. Up To and Including 2 Inches:
1. Class 150 bronze body, bronze trim, renewable seat and disc, with composition disc, threaded ends.
C. Over 2 Inches:
1. Class 150, iron body, bronze trim, bronze or bronze faced rotating swing disc, renewable disc and seat, flanged ends.

2.09 BALANCING VALVES
A. Manufacturers:
B. Construction:
1. 1/2" to 2" Pipe Size
   a. Bronze body, brass ball construction with glass and carbon filled TFE seat rings. Valves to have differential pressure read-out ports across valve seat area. Read-out ports shall have integral EPT insert and check valve. Valve bodies shall have 1/4" tapped drain/purge point. Valve to have memory stop feature and integral calibrated nameplate with position indication. 300 psig design pressure, NPT connections. 250 F operating temperature.
2. 2-1/2" to 12" Pipe Size
   a. Cast iron, flanged construction with 125 psig flanged connections suitable up to 175 psig working pressure at 250 F. Valves 2-1/2" - 3" shall have a brass ball with glass and carbon filled TFE seat rings. Valves 4" - 12" shall be fitted with a bronze seat, replaceable bronze disc with EPDM seal insert, and stainless steel stem. Valves shall have memory stop feature and calibrated nameplate with position indication.

PART 3 EXECUTION
3.01 PREPARATION
A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.
B. Remove scale and dirt on inside and outside before assembly.
C. Prepare piping connections to equipment using jointing system specified.
D. Keep open ends of pipe free from scale and dirt. Protect open ends with temporary plugs or caps.
E. After completion, fill, clean, and treat systems. Refer to Section 23 25 00 for additional requirements.

3.02 INSTALLATION
A. Install in accordance with manufacturer's instructions.
B. Route piping in orderly manner, parallel to building structure, and maintain gradient.
C. Install piping to conserve building space and to avoid interference with use of space.
D. Group piping whenever practical at common elevations.
E. Sleeve pipe passing through partitions, walls and floors.
F. Slope piping and arrange to drain at low points.

G. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.

H. Grooved Joints:
   1. CHW only
   2. Install in accordance with the manufacturer’s latest published installation instructions.
   3. Gaskets to be suitable for the intended service, molded, and produced by the coupling manufacturer.

I. Provide stainless steel escutcheon plates or other trim/flashings wherever pipes penetrate walls above grade, exterior and interior.

J. Inserts:
   1. Provide inserts for placement in concrete formwork.
   2. Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.

K. Pipe Hangers and Supports:
   1. Install in accordance with ASME B31.9.
   2. Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.
   3. Provide copper plated hangers and supports for copper piping.
   4. Prime coat exposed steel hangers and supports. Hangers and supports located in crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed.

L. Provide clearance in hangers and from structure and other equipment for installation of insulation and access valves and fittings.

M. Prepare unfinished pipe, fittings, supports, and accessories, ready for finish painting.

N. Install valves with stems upright or horizontal, not inverted.

3.03 TESTING

A. Unless otherwise noted, hydrostatically test all piping installed under this contract to 1-1/2 times the normal working pressure or 150 psig, whichever is higher for a period of not less than 4 hours with no visible signs of leakage.

B. Provide necessary caps or blinds to protect equipment not rated for test pressure (safety valves, regulators, etc.).

C. Pneumatic Testing:
   1. Pneumatic testing is expressly prohibited on any non-metallic piping.
   2. Other than as excepted above, pneumatic testing will not be considered without written consent from District or Engineer, and substantiation as to why hydrotesting is inapplicable. Additional testing requirements and measures may be required for a pneumatic test and will be considered on a case-by-case basis.

D. Reports: Submit test reports for all pipeline sections tested per Submittals requirements in Part 1 of this specification.

END OF SECTION
PART 1 GENERAL

1.01 SECTION INCLUDES

A. Air vents.
B. Strainers.
C. Combination pump discharge valves.

1.02 REFERENCE STANDARDS

A. ASME (BPV VIII, 1) - Boiler and Pressure Vessel Code, Section VIII, Division 1 - Rules for Construction of Pressure Vessels; The American Society of Mechanical Engineers; 2007.

1.03 SUBMITTALS

A. See Division 1 for submittal procedures.
B. Product Data: Provide product data for manufactured products and assemblies required for this project. Include component sizes, rough-in requirements, service sizes, and finishes. Include product description, model and dimensions.
C. Manufacturer's Installation Instructions: Indicate hanging and support methods, joining procedures.
D. Maintenance Data: Include installation instructions, assembly views, lubrication instructions, and replacement parts list.

1.04 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Accept valves on site in shipping containers with labeling in place. Inspect for damage.
B. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.
C. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.

PART 2 PRODUCTS

2.01 AIR VENTS

A. Manufacturers:
   4. Substitutions: See Division 1.
B. Manual Type: Short vertical sections of 2 inch diameter pipe to form air chamber, with 1/8 inch brass needle valve at top of chamber.
C. Automatic Float Type:
   1. Standard Duty: Brass or semi-steel body, copper, polypropylene, or solid non-metallic float, stainless steel valve and valve seat; suitable for system operating temperature and pressure; with isolating valve.
   2. High Capacity: Cast iron body and cover, float, bronze pilot valve mechanism suitable for system operating temperature and pressure; with isolating valve.

2.02 STRAINERS

A. Manufacturers:
2. Bell & Gossett: www.bellgossett.com

**B. Size 2 inch and Under:**
1. Screwed brass or iron body for 175 psi working pressure, Y pattern with 1/32 inch stainless steel perforated screen.

**C. Size 2-1/2 inch to 4 inch:**
1. Flanged iron body for 175 psi working pressure, Y pattern with 3/64 inch stainless steel perforated screen.

**D. Size 5 inch and Larger:**
1. Flanged iron body for 175 psi working pressure, basket pattern with 1/8 inch stainless steel perforated screen.

### 2.03 COMBINATION PUMP DISCHARGE VALVES

**A. Manufacturers:**
1. Bell & Gossett; Model 3DS.

**B. Valves:** Straight or angle pattern, flanged cast-iron valve body with bolt-on bonnet for 175 psi operating pressure, non-slam check valve with spring-loaded bronze disc and seat, stainless steel stem, and calibrated adjustment permitting flow regulation.

### PART 3 EXECUTION

#### 3.01 INSTALLATION

**A. Install specialties in accordance with manufacturer's instructions.**

**B. Provide manual air vents at system high points and as indicated.**

**C. For automatic air vents in ceiling spaces or other concealed locations, provide vent tubing to nearest drain.**

**D. Provide valved drain and hose connection on strainer blow down connection.**

**END OF SECTION**
PART 1 GENERAL

1.01 SECTION INCLUDES
A. In-line pumps.

1.02 REFERENCE STANDARDS

1.03 SUBMITTALS
A. See Division 1 for submittal procedures.
B. Product Data: Provide certified pump curves showing performance characteristics with pump and system operating point plotted. Include NPSH curve when applicable. Include electrical characteristics and connection requirements.
C. Manufacturer's Installation Instructions: Indicate hanging and support requirements and recommendations.
D. Millwright's Certificate: Certify that base mounted pumps have been aligned.
E. Operation and Maintenance Data: Include installation instructions, assembly views, lubrication instructions, and replacement parts list.

1.04 QUALITY ASSURANCE
A. Manufacturer Qualifications: Company specializing in manufacture, assembly, and field performance of pumps, with minimum three years of documented experience.

PART 2 PRODUCTS

2.01 MANUFACTURERS
A. ITT Bell & Gossett; Series 80. www.bellgossett.com.
B. Substitutions: See Division 1.

2.02 HVAC PUMPS - GENERAL
A. 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.
B. Products Requiring Electrical Connection: Listed and classified by UL or testing agency acceptable to authority having jurisdiction as suitable for the purpose specified and indicated.

2.03 IN-LINE PUMPS
A. Type: Single stage, close coupled, radially split casing, for 175 psi maximum working pressure.
B. Casing: Cast iron, with suction and discharge gage ports, renewable bronze casing wearing rings, seal flush connection, drain plug, flanged suction and discharge.
C. Impeller: Bronze, fully enclosed, keyed to motor shaft extension.
D. Shaft: Stainless steel.
E. Seal: Manufacturer's standard seal, 225 degrees F maximum continuous operating temperature.
F. Motor: TEFC with dripproof enclosure.

PART 3 EXECUTION

3.01 PREPARATION
A. Verify that electric power is available and of the correct characteristics.
3.02 INSTALLATION

A. Install in accordance with manufacturer's instructions.
B. Provide access space around pumps for service. Provide no less than minimum space recommended by manufacturer.
C. Decrease from line size with long radius reducing elbows or reducers. Support piping adjacent to pump such that no weight is carried on pump casings.
D. Provide line sized shut-off valve and strainer on pump suction, and line sized soft seat check valve and balancing valve on pump discharge.
E. Lubricate pumps before start-up.

END OF SECTION
PART 1 GENERAL

1.01 SECTION INCLUDES
A. Cleaning of piping systems.

1.02 SUBMITTALS
A. See Division 1 for Submittal Procedures.
B. Product Data: Provide chemical treatment materials, chemicals, and equipment including electrical characteristics and connection requirements.
C. Manufacturer's Installation Instructions: Indicate placement of equipment in systems, piping configuration, and connection requirements.
D. Manufacturer's Field Reports: Indicate start-up of treatment systems when completed and operating properly. Indicate analysis of system water after cleaning and after treatment.
E. Project Record Documents: Record actual locations of equipment and piping, including sampling points and location of chemical injectors.
F. Operation and Maintenance Data: Include data on chemical feed pumps; agitators, and other equipment including spare parts lists, procedures, and treatment programs. Include step by step instructions on test procedures including target concentrations.

1.03 QUALITY ASSURANCE
A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience. Company shall have local representatives with water analysis laboratories and full time service personnel.
B. Installer Qualifications: Company specializing in performing the type of work specified in this section, with minimum three years of experience and approved by manufacturer.

1.04 REGULATORY REQUIREMENTS
A. Conform to applicable code for addition of non-potable chemicals to building mechanical systems and to public sewage systems.

1.05 COORDINATION
A. Coordinate with chemical supplier for means and methods of flushing and cleaning operations.
B. Coordinate with Owner for final filling and chemical treatment of the chilled water system. Chilled and heating hot water system may be final filled from the Central Plant to maintain water treatment quality.

PART 2 PRODUCTS

2.01 MANUFACTURERS
B. Substitutions: See Division 1.

2.02 MATERIALS
A. Temporary Materials
   1. Pumps: Provide temporary circulating/injection pumps to flush and clean the new piping systems. Pumps shall be of the size and capacity as required for the chemical cleaning operation as recommended by the chemical supplier/cleaning agency.
   2. Piping Systems: Provide necessary pipe, valves, fittings, hoses, etc. as required to complete piping loops to provide circulation necessary for cleaning operations.
   3. Power: Provide necessary power connections and safety devices to operate temporary pumps.
   4. Provide temporary water meters as required for determination of system volumes.
B. System Cleaner:
   1. Manufacturers:
      b. Substitutions: See Division 1.
   2. Liquid alkaline compound with emulsifying agents and detergents to remove grease and petroleum products; sodium tripoly phosphate and sodium molybdate.
   3. Biocide chlorine release agents such as sodium hypochlorite or calcium hypochlorite.

C. Closed System Treatment (Chilled Water & Heating Hot Water - steel):
   1. Manufacturers:
      b. Substitutions: See Division 1.
   2. Sequestering agent to reduce deposits and adjust pH.
   3. Corrosion inhibitors Molybdate based inhibitor. Provide a 15 gallon container of treatment listed above - deliver to the Central Plant. DO NOT treat system. System will be filled from Central Plant treated water. Note that fill rate will be extremely prolonged due to limited make up rate of the Central Plant.

PART 3 EXECUTION

3.01 PREPARATION
   A. Provide taps/nozzles and valves for temporary pump connections.
   B. Do not chemically clean permanent pumps, heat transfer devices or control components. Isolate prior to cleaning.
   C. Verify that electric power is available and of the correct characteristics.

3.02 CLEANING SEQUENCE
   A. Clean the heating hot water and chilled water systems installed under this contract.
   B. Concentration:
      1. As recommended by manufacturer.
   C. Temporary Materials
      1. Pumps: Provide temporary circulating/injection pumps to flush and clean the new piping systems. Pumps shall be of the size and capacity as required for the chemical cleaning operation as recommended by the chemical supplier/cleaning agency.
      2. Piping Systems: Provide necessary pipe, valves, fittings, hoses, etc. as required to complete piping loops to provide circulation necessary for cleaning operations. Provide necessary temporary piping and hoses to drain systems to sanitary sewer.
      3. Power: Provide necessary power connections and safety devices to operate temporary pumps.
   D. Draining: All system draining shall be to sanitary sewer.
   E. Hot Water Heating and Chilled Water Systems:
      1. Provide temporary bypasses, nozzles, valves and crossovers to allow circulation of systems without the use of the permanent pumps (if any).
      2. Fill the system with water and initially circulate and flush the system without cleaner to remove large debris.
      3. After the initial flush is complete, circulate system with temporary pumps while injecting chemical. Test system at remote points to ensure chemical is being distributed throughout the system. Circulate with chemicals for a duration as recommended by the chemical supplier.
      4. Drain and flush system with clean water. Test for residual chemical. Re-flush as required to attain dilution as per supplier's recommendation.
      5. Fill hydronic systems with clean water and treat with final chemicals.
      6. Energize steam systems with plant steam, warming up gradually.
F. Use neutralizer agents on recommendation of system cleaner supplier and approval of Engineer.

G. Remove, clean, and replace strainer screens.

3.03 INSTALLATION

A. Install in accordance with manufacturer's instructions.

END OF SECTION
SECTION 23 31 00
HVAC DUCTS AND CASINGS

PART 1 GENERAL
1.01 SECTION INCLUDES
A. Metal ductwork.

1.02 REFERENCE STANDARDS
C. SMACNA (DCS) - HVAC Duct Construction Standards; 2005.
D. SMACNA Guidelines for Seismic Restraints of Mechanical Systems

1.03 SUBMITTALS
A. See Division 1 for submittal procedures.
B. Product Data: Provide data for duct materials.
C. Project Record Documents: Record actual locations of ducts and duct fittings. Record changes in fitting location and type. Show additional fittings used.

1.04 FIELD CONDITIONS
A. Do not install duct sealants when temperatures are less than those recommended by sealant manufacturers.
B. Maintain temperatures within acceptable range during and after installation of duct sealants.

PART 2 PRODUCTS
2.01 DUCT ASSEMBLIES

2.02 MATERIALS
A. Double Wall Ducts
   1. All exterior ductwork shall be constructed of double wall, insulated, galvanized sheet metal construction, unless the plans specifically call for a different type of construction. Minimum outer shell metal thickness is 22 ga. Inner and outer shell thicknesses shall both be determined by SMACNA Standards for the size of the duct, and pressure of the system. Insulation thickness shall be 2". Connectors shall be 4 bolt type, with continuous butyl gasket. For more info on insulation and jacketing, see section 23 07 13, 2.04.

2.03 DUCTWORK FABRICATION
A. Fabricate and support in accordance with SMACNA HVAC Duct Construction Standards and as indicated.
B. Provide duct material, gages, reinforcing, and sealing for operating pressures indicated.
C. Construct T's, bends, and elbows with radius of not less than 1-1/2 times width of duct on centerline. Where not possible and where rectangular elbows must be used, provide air foil turning vanes of perforated metal with glass fiber insulation.
D. Increase duct sizes gradually, not exceeding 15 degrees divergence wherever possible; maximum 30 degrees divergence upstream of equipment and 45 degrees convergence downstream.
E. Fabricate continuously welded round and oval duct fittings in accordance with SMACNA HVAC Duct Construction Standards.
PART 3 EXECUTION
3.01 INSTALLATION

A. Install in accordance with manufacturer's instructions.
B. Duct sizes indicated are inside clear dimensions. For double wall ducts, maintain sizes inside lining.
C. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.
D. Install ductwork in accordance with SMACNA Guidelines for Seismic Restraints of Mechanical Systems.

END OF SECTION
SECTION 23 33 00
AIR DUCT ACCESSORIES

PART 1 GENERAL
1.01 SECTION INCLUDES
A. Air turning devices/extractors.

1.02 REFERENCE STANDARDS
A. SMACNA (DCS) - HVAC Duct Construction Standards; 2005.

1.03 SUBMITTALS
A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
B. Product Data: Provide for shop fabricated assemblies including hardware used.

PART 2 PRODUCTS
2.01 AIR TURNING DEVICES/EXTRACTORS
A. Manufacturers:
B. Turning vanes shall be a true airfoil design; smoothly-rounded entry nose with extended trailing edge. Generated sound power level shall not exceed 54 decibels in band 4 at 2,000 FPM, with a duct size of 24 x 24.
C. Assemblies shall be fabricated with side rails; vanes installed on design centers across the full diagonal dimension of the elbow.
D. Multi-blade device with blades aligned in short dimension; steel construction; with individually adjustable blades, mounting straps.
E. Multi-blade device with radius blades attached to pivoting frame and bracket, steel construction, with push-pull operator strap.

PART 3 EXECUTION
3.01 INSTALLATION
A. Install accessories in accordance with manufacturer's instructions, NFPA 90A, and follow SMACNA HVAC Duct Construction Standards.
PART 1 GENERAL

1.01 SECTION INCLUDES

A. Design, performance criteria, controls and installation requirements for Custom Air Handling Units.

1.02 REFERENCES

B. AMCA/ANSI Standard 204: Balance Quality and Vibration Levels for Fans
C. AMCA Standard 210: Laboratory Methods of Testing Fans for Ratings
D. AMCA Standard 300: Reverberant Room Method for Sound Testing of Fans
E. AMCA Standard 500: Test Method for Louvers, Dampers and Shutters
F. ARI Standard 410: Forced-Circulation Air-Cooling and Air-Heating Coil
G. ASHRAE Standard 52: Gravimetric and Dust Spot Procedures for Testing Air Cleaning Devices Used in General Ventilation for Removing Particulate Matter
J. ASTM A-525: Specification for General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process

1.03 SUBMITTALS

A. Submit shop drawings and product data in accordance with Division 1.
B. Submittals shall include the following:
   1. Dimensioned plan and elevation view drawings, including motor starter and control cabinets, required clearances, and location of all field connections.
   2. Summary of all auxiliary utility requirements such as: electricity, water, compressed air, etc. Summary shall indicate quality and quantity of each required utility.
   3. Ladder type schematic drawing of the power and ancillary utility field hookup requirements, indicating all items that are furnished.
   4. Manufacturer's performance of each unit. Selection shall indicate, as a minimum, the following:
      a. Input data used for selection.
      b. Model number of the unit.
      c. Net capacity.
      d. Rated load amp draw.
      e. Noise levels produced by equipment.
      f. Fan curves.
      g. Approximate unit shipping weight.

1.04 OPERATION AND MAINTENANCE DATA

A. Include data on design, inspection and procedures related to preventative maintenance. Operation and Maintenance manuals shall be submitted at the time of unit shipment.

1.05 QUALIFICATIONS

A. Manufacturer shall be a company specializing in the design and manufacture of commercial custom HVAC equipment. Manufacturer shall have been in production of custom HVAC equipment for a minimum of 5 years.
B. Each unit shall bear an ETL or UL label under UL Standard 1995 indicating that the complete unit is listed as an assembly. ETL or UL listing of individual components, or control panels only, is not acceptable.

1.06 DELIVERY, STORAGE, AND HANDLING
A. Deliver, store, protect and handle products to site under the supervision of the district.

1.07 WARRANTY
A. The complete unit shall be covered by a parts warranty issued by the manufacturer covering the first year of operation. This warranty period shall start upon receipt of start-up forms for the unit or eighteen months after the date of shipment, whichever occurs first.
B. The installing contractor shall provide labor warranty during the unit's first year of operation.

PART 2 PRODUCTS
2.01 ACCEPTABLE MANUFACTURERS
A. Provide custom outdoor air handling units as manufactured by Temtrol as the basis-of-design.

2.02 GENERAL
A. Furnish and install where shown on the plans, mechanical frame style air handling units designed for outdoor application with construction features as specified below. The units shall be provided and installed in strict accordance with the specifications. All units shall be complete with all components and accessories as specified. Any exceptions must be clearly defined. The contractor shall be responsible for any additional expenses that may occur due to any exception made.

2.03 FACTORY TESTING AND QUALITY CONTROL
A. Standard Factory Tests: The fans shall be factory run tested to ensure structural integrity and proper RPM. All electrical circuits shall be tested to ensure correct operation before shipment of unit. Units shall pass quality control and be thoroughly cleaned prior to shipment.

2.04 UNIT CONSTRUCTION DESCRIPTION
A. General: Provide factory-fabricated air handling units with capacity as indicated on the schedule. Units shall have overall dimensions as indicated and fit into the space available with adequate clearance for service as determined by the Engineer. Units shall be completely assembled. Multiple sectioned units shall be shipped as a single factory assembled piece. Units shall be furnished with sufficient gasket and bolts for reassembly in the field by the contractor. Unit manufacturer shall provide certified ratings conforming to the latest edition of AMCA 210, 310, 500 and ARI 410. All electrical components and assemblies shall comply with NEMA standards. Unit internal insulation must have a flame spread rating not over 25 and smoke developed rating no higher than 50 complying with NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems." Units shall comply with NFPA 70, "National Electrical Code," as applicable for installation and electrical connections of ancillary electrical components of air handling units. Tags and decals to aid in service or indicate caution areas shall be provided. Electrical wiring diagrams shall be attached to the control panel access doors. Operation and maintenance manuals shall be furnished with each unit. Units shall be UL or ETL listed.

B. Unit Base - Floor: Unit perimeter base shall be completely welded and fabricated using heavy gauge structural steel tubing. (Note: bolted bases are not acceptable) C-Channel cross supports shall be welded to perimeter base steel tubing and located on maximum 24" centers to provide support for internal components. Base rails shall include lifting lugs welded to perimeter base at the corner of the unit or each section if de-mounted. Entire base frame is to be painted with a phenolic coating for long term corrosion resistance. Internal walk-on floor shall be 18 gauge G90 galvanized steel. The outer sub-floor of the unit shall be made from 20 gauge G90 galvanized steel. The floor cavity shall be spray foam insulated with floor seams gasketed for thermal break and sealed for airtight/watertight construction. Where access is provided to the unit interior, floor openings shall be covered with walk on phenolic coated steel
safety grating. Single wall floors with glued and pinned insulation and no sub floor are not acceptable. Base frame shall be attached to the unit at the factory.

1. WALK-ON FLOOR inserts:
   a. Standard floor: Temtrol
   b. Thermal break construction: Mechanically fastened caulk seams.
      1) 16 gauge G90 galvanized steel.

2. SUB-FLOOR inserts: Temtrol
   a. Standard subfloor:
      1) 20 gauge G90 galvanized steel

C. Unit Casing - The construction of the air handling unit shall consist of a (1" x 2") steel frame with formed 16 gauge exterior casing panels. The exterior casing panels shall be attached to the gasketed (1 x 2) steel frame with corrosion resistant fasteners. All casing panels shall be completely removable from the unit exterior without affecting the unit's structural integrity. The air handling unit casing shall be of the "no-through-metal" design. The casing shall incorporate insulating thermal breaks as required so that, when fully assembled, there's no path of continuous unbroken metal to metal conduction from inner to outer surfaces. Provide necessary support to limit casing deflection to L/200 of the narrowest panel dimension. If panels cannot meet this deflection, additional internal reinforcing is required. All panel seams shall be caulked and sealed for an airtight unit. Leakage rates shall be less than 1% at design static pressure or 9" W.C. whichever is greater.

1. "Casing Material" options:
   a. Standard Panel:
      1) 16 gauge galvanized steel with fiberglass insulation

2. The exterior panel finish shall be: STANDARD COLOR "SANDSTONE"
   a. Painted with a polyester resin coating designed for long term corrosion resistance meeting or exceeding (ASTM B-117) Salt Spray Resistance at 95 degrees F. 2500 hrs. and (ASTM D-2247) Humidity Resistance at 95 degrees F. 2500 hrs. The color shall be sandstone.

D. Double Wall Liner - Each unit shall have double wall construction with 16 gauge solid galvanized liner in the exterior section. 20 gauge perforated galvanized liner in the interior section. The double wall interior panel shall be removable from the outside of the unit without affecting the structural integrity of the unit. Perforated sections shall be furnished with BGF 7628/252L fiberglass cloth used to prohibit the erosion of the insulation into the air stream.

E. Fiberglass Panel ITF = 3" - (R12.5), 4" - (R17)
   1. Insulation - Cabinet to be insulated with a full 3" (R12.5). The insulation shall have an effective thermal conductivity (C) of 0.24 (BTU in./sq.ft. F) and a noise reduction coefficient (NRC) of 0.70 / per inch thick (based on a type "A" mounting). The coefficients shall meet or exceed a 3.0 P.C.F. density material rating. Insulation shall meet the erosion requirements of UL 181 facing the air stream and fire hazard classification of 25/50 (per ASTM-84 and UL 723 and CAN/ULC S102-M88) and meet NFPA 90A and 90B. All insulation edges shall be encapsulated within the panel. All perforated sections shall have Micromat or equal insulation with non-woven mat facing 5000 fpm rating and non-hygroscopic fibers as manufactured by Johns Manville or approved equal.

F. Foam Panel: Insulation - Base to be insulated with a full (R20) 3" thick closed cell foam insulation. Foam shall be ecomat 0-, 0- (Non VOC) UL 94HF1 rated. All insulation edges shall be encapsulated within the panel. All field penetrations must be completely sealed by installing contractor.
   Note: Non UL 94HF1 rated foam is not allowed.

G. Access Doors - The unit shall be equipped with a solid double wall insulated (same as the unit casing), hinged access doors as shown on the plans. The doorframe shall be extruded aluminum, foam filled with a built in thermal break barrier and full perimeter gasket. The door hinge assembly shall be completely adjustable die cast stainless steel. There shall be a minimum of two heavy duty handles per door. Provide ETL, UL 1995, and CAL-OSHA approved tool operated safety latch on all fan section access doors.

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DSA Appl. #01-114479
1. Access doors shall be provided with a 10 x 10 dual thermal pane safety glass window with the exception of the CW Coil section.

2.05 UNIT COMPONENT DESCRIPTION

A. Unit Fans - All fans shall meet the air flow performance specified and shall not exceed the brake horsepower or sound power levels specified on the mechanical equipment schedule. Fan performance shall be based on testing and be in accordance with AMCA Standards 210 and 300. All fans shall have a steep pressure/volume curve. Fan shaft shall be turned, ground and polished solid steel rated at maximum RPM below critical speed. Fan wheel and sheaves shall be keyed to the shaft. Fan shall be balanced per ANSI / AMCA 204-96 fan application category BV-3 using a digital signal analyzer at the design RPM with belts and drives in place to a vibration velocity less than or equal to 0.157 inches per second measured horizontal and vertical at each bearing pad. Vibration amplitudes are in inches/second-Peak. All values are filter-in at the fan speed. Fan assemblies shall be designed for heavy-duty industrial applications. Fan framing assemblies shall be fabricated from structural steel. Formed load bearing members are not acceptable. The structural steel shall be electrically welded together to form a rigid integral base. Fan assemblies shall be independently isolated with spring-type vibration isolators. Inlet cones shall be precision spun or die formed. Inlet cones shall be aerodynamically matched to the wheel side plate to provide streamlined airflow in the wheel and ensure full loading of the blades.

B. FANWALL TECHNOLOGY (FWT)

1. The multiple fan array systems shall include multiple, direct driven, arrangement 4 plenum fans constructed per AMCA requirements for the duty specified class III as required. Class I fans are not acceptable. Fans shall be rated in accordance with and certified by AMCA for performance. All fans shall be selected to deliver the specified airflow quantity at the specified operating Total Static Pressure and specified fan/motor speed. The fan array shall be selected to operate at a system Total Static Pressure that does not exceed 90% of the specified fan's peak static pressure producing capability at the specified fan/motor speed. Each fan/motor cube or cell shall include a minimum 10 gauge, G 90 Galvanized steel intake wall, 100 aluminum spun fan inlet funnel, and a 7 gauge HR steel (painted) motor support plate rail and structure. All motors shall be standard foot mounted type TEAO selected at the specified operating voltage, RPM, and efficiency as specified or as scheduled elsewhere. Motors shall meet the requirements of NEMA MG-1 Part 30 and 31, section 4.4.2. Motors shall be as manufactured by Baldor, Siemens, or Toshiba for use in multiple fan arrays that operate at varying synchronous speeds as driven by an approved VFD. Motor HP shall not exceed the scheduled HP as indicated in the AHU equipment schedule(s). Steel cased motors and/or ODP motors are not acceptable. All motors shall include permanently sealed (L10-400,000hr) bearings and AEGIS shaft grounding to protect the motor bearings from electrical discharge machining due to stray shaft currents. Each fan/motor assembly shall be dynamically balanced to meet AMCA standard 204-96, exceeding category BV-5, to meet or exceed an equivalent Grade G.55, producing a maximum rotational imbalance of .03" per second peak, filter in (.55mm per second peak, filter in). Fan and motor assemblies submitted for approval incorporating larger than 22" wheel size and 215 T frames size motors shall be balanced in three orthogonal planes to demonstrate compliance with the G.55 requirement with a maximum rotational imbalance of .03" per second peak filter in (.55 mm per second peak, filter in). Copies of the certified balancing reports shall be provided with the unit O&M manuals at the time of shipment. Submittals that do not include a statement of compliance with this requirement will be returned to the contractor without review.

2. The multiple fan array AHU unit shall provide the specified acoustical performance as scheduled for the unit supply discharge opening(s), RA opening(s), and the OSA and Exhaust air opening(s).

3. The fan array shall consist of multiple fan and motor "cubes" or "cells," spaced in the air way tunnel cross section to provide a uniform air flow and velocity profile across the entire air way tunnel cross section and components contained therein. In order to assure uniform velocity profile in the AHU cross section, the fan cube dimensions must be variable, such
that each fan rests in an identically sized cube or cell, and in a spacing that must be such that the submitted array dimensions fill a minimum of 90% of the cross sectional area of the AHU air way tunnel. There shall be no blank off plates or "spacers" between adjacent fan columns or rows to position the fans across the air way tunnel. The array shall produce a uniform air flow profile and velocity profile within the airway tunnel of the air handling unit to equal the specified cooling coil and/or filter bank face velocity by +/- 10% when measured at a point 36" from the intake side of the fan array intake plenum wall, and a distance of 72" from the discharge side of the fan array intake plenum wall. Submittals for units providing less than the scheduled quantity of fans and/or spacing of the fans for multifeature fan arrays shall submit CFD modeling of the air flow profile for pre-bid approval that indicates uniform velocity and flow across all internal components without increasing the length of the AHU unit or changing the aspect ratio of the unit casing as designed.

4. Each individual cube or cell in the multiple fan arrays shall be provided with an integral back flow prevention device that prohibits recirculation of air in the event a fan or multiple fans become disabled. The system effects for the back flow prevention device(s) shall be included in the criteria for the TSP determination for fan selection purposes, and shall be indicated as a separate line item SP loss in the submittals. Submitted AHU performance that does not indicate allowance for system effects for the back flow prevention device(s) and the system effect for the fan and motor enclosure in which each fan is mounted, will be returned to the contractor disapproved and will need to be resubmitted with all of the requested information included for approval. Back Draft Damper performance data that is per AMCA ducted inlet and discharge arrangements will not be accepted. Damper data must be for the specific purpose of preventing back flow in any disabled fan cube and that is mounted directly at the inlet of each fan. Motorized dampers for this purpose are not acceptable. Submitted fan performance data which only reflect published performance for individual fans in AMCA arrangement "A" free inlet and discharge will not be accepted. AHU Manufacturers that do not manufacture the fans being submitted on must provide certified performance data for fans as installed in the AHU unit with Back Draft damper effects included. At the sole discretion of the engineer, such performance testing may be witnessed by the engineer and/or the owner's representative.

5. Each fan motor shall be individually wired to a control panel containing a single VFD. Provide space within panel for the controls to accommodate 11"W X 13"H X 3" thick controller. Each VFD shall be sized for the total connected HP for all fan motors contained in the fan array. Wire sizing shall be determined, and installed, in accordance with applicable NEC standards and local code requirements. The multiple fan array electrical panel shall include system optimization controls to actively control fan speed and to enable and disable fans in the multiple fan array. The number of active fans in the array shall be automatically determined, and the speed of the enabled fans shall be adjusted to produce the required coincidental flow and pressure at the perimeter boundary of the unit at substantially peak efficiency. The system optimization controls shall continuously monitor required flow and pressure and shall automatically optimize the operating array configuration and speed for peak efficiency. The system, optimization controls shall be provided that will interface with, and be compatible with the BAS as specified elsewhere. It is the responsibility of the contractor to assure that the fan system optimization controls are compatible with the BAS system. System optimization controls shall be provided by the AHU unit manufacturer to assure single source responsibility for fan volume controls, and shall require only an input control signal from the controls contractor for SP or flow for proper operation of the system optimization controls. When specified, the AHU unit manufacturer shall provide a single communication interface with the BAS and shall coordinate with the controls contractor to make sure that all necessary data points are communicated.

6. Each fan & motor assembly shall be removable through a 24" wide, free area, access door located on the discharge side of the fan wall array without removing the fan wheel from the motor. All fan/motor access doors shall open against pressure.

MOTOR CIRCUIT PROTECTION:

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All motors in the FANWALL Array shall be provided with individual Motor Protection for thermal overload protection. All motor circuit protectors can be located in starting device enclosure or, if required by design, in a separate enclosure. Motor circuit protector enclosure must be located and mounted at a minimal distance from motors in the FANWALL Array. Provide remote indication by means of aux contacts wired in series.

Remote indication: Auxiliary contacts wired in series.

Pilot Lights: Multiple (one per fan) cover mounted pilot lights for local monitoring.

FANWALL TECHNOLOGY (FWT) CONTROL:

FANWALL TECHNOLOGY (FWT) WITH VARIABLE FREQUENCY DRIVE:

As required by system design, provide one ABB Variable Frequency Drive for normal operation for each supply fan and return fan array. Intec Solutions shall startup VFD. Provide service disconnect with fuses or circuit breaker.

C. Heat Transfer Coils - Water Coil

1. All coil assemblies shall be leak tested under water at 315 PSIG and PERFORMANCE is to be CERTIFIED under ARI Standard 410. Coils exceeding the range of ARI standard rating conditions shall be noted.

2. Cooling coils shall be mounted on stainless steel support rack to permit coils to slide out individually from the unit. Provide intermediate drain pans on all stacked cooling coils. The intermediate pan shall drain to the main drain pan through a copper downspout. Water coils shall be constructed of seamless copper tubing mechanically expanded into fin collars. All fins shall be continuous within the coil casing to eliminate carryover inherent with a split fin design. Fins are die formed Plate type.

3. Headers are to be seamless copper with die formed tube holes.

4. Connections shall be male pipe thread (MPT) Schedule 40 Red Brass with 1/8" vent and drain provided on coil header for coil drainage. All coil connections shall be extended to the exterior of the unit casing by the manufacturer. Coils shall be suitable for 250 PSIG working pressure. Intermediate tube supports shall be supplied on coils over 44" fin length with an additional support every 42" multiple thereafter.

5. Water coils shall have the following construction:

- Standard 5/8":
  - 5/8" o.d. x 0.20" wall copper tube
  - 0.006" Copper fins
  - 16 gauge

Stainless Steel

D. Condensate / Drain Pans - IAQ style drain pans shall be provided under all cooling coils as shown on the drawings. The drain pan shall be fabricated from 16 gauge 304 stainless steel. All pans are to be triple pitched for complete drainage with no standing water in the unit. They shall be insulated minimum 3-inch "Double Bottom" construction with welded corners. Provide stainless steel, 1-1/4" MPT drain connection extended to the exterior of the unit base rail. Units in excess of 159 inches shall have drain connections on both sides. All drain connections shall be piped and trapped separately for proper drainage.
E. Filters - Provide filters of the type indicated on the schedule. Factory fabricated filter sections shall be of the same construction and finish as the unit. Face loaded pre and final filters shall have Type 8 frames as manufactured by BLC, FARR or equal. Filter racks over 72" in length shall require an angle center reinforcement support. Side service filter racks shall be fabricated from no less than 16 gauge galvanized steel and include hinged access doors on both sides of the unit or as indicated on unit drawings. Internal blank-offs shall be provided by the air unit manufacturer as required to prevent air bypass around the filters.

1. Filter Gauge: Each filter bank shall be furnished with Magnethelic 2003, Signal Flag, Hinged Cover.
2. Medium Efficiency MERV 8 Pleated Filters - Provide 2" filters as specified on schedule on drawings. The filters shall be as manufactured by AAF, FARR or equal. Filters shall be in compliance with ANSI/UL 900 - Test Performance of Air Filters.
3. High Efficiency MERV 13 Rigid Filters - Provide (12" deep) filters as specified on schedule on drawings. The filters shall be listed as Class II under UL Standard 900. The filters shall be as manufactured by AAF, FARR or equal. Filters shall be in compliance with ANSI/UL 900 - Test Performance of Air Filters.

F. Dampers - Ruskin CD-60 or approved equal. Provide Class 1 rated, ultra low leak dampers (less than 3 cfm/sq ft. @1" w.g.) as indicated on the unit drawings. Low leakage dampers shall have extruded aluminum airfoil blades. Flat or formed metal blades are not acceptable. The damper blade shall incorporate santoprene rubber edge seals and zinc plated or stainless steel tubular steel shaft for a non-slip operation. Shaft bearings shall be spherical - non corrosive nylon to eliminate friction and any metal to metal contact. Damper jamb seals shall be UV rated, nylon glass reinforced or stainless steel spring arcs designed for a minimum air leakage and smooth operation. Damper linkage shall be concealed within a 16 gauge galvanized steel frame.

G. Rain Hoods - Rain hoods shall be fabricated from same material as unit casing with 1/4" wire mesh inlet screen. Hoods sized to minimize moisture carry over.

H. Louvers:
1. Exhaust Air applications - Provide Temtrol DL6 extruded aluminum stationary louvers, drainable type with built in downspouts and birdscreen. Blades shall be housed inside a 16 ga. galvanized steel frame mounted to the unit exterior. Louver finish to match exterior unit finish.
2. Outside Air applications - RUSKIN EME3625. Louvers shall be used at O/A location. Louvers shall be stationary, drainable type with built in downspouts and furnished with birdscreen. Blades shall be vertical and housed inside an aluminum frame mounted to the unit exterior. Louver finish to match exterior unit finish.

2.06 ELECTRICAL POWER AND CONTROLS

A. All electrical and automatic control devices not previously called out or listed below are to be furnished and installed in the field by OTHERS.
B. All wiring shall be (75 degrees C) insulated copper wires.
C. The unit shall feature a mounted permanent nameplate displaying at a minimum the manufacturer, serial number, model number, current, amps and voltage. The unit must have an ETL or UL Listed and bear the appropriate mark.
D. Conduit shall consist of a combination of EMT or flexible metal conduit as required. Liquidtight flexible metal conduit may be used outside the air tunnel for wet locations.
E. The unit shall feature a main non-fused disconnect or the proper amp rating to allow shutoff of all electrical motors and control items.
F. The fan motors shall be wired to a junction box mounted on the unit exterior.
G. Unit Convenience Features
1. Specified sections on schedule shall be equipped with a vapor-proof 100 watt service light with guard.
2. Lights shall be controlled by one light switch mounted adjacent to the supply air fan access door.
3. Furnish a 120 volt GFI duplex convenience outlet on the exterior of AHU-4, 8 and 9 as indicated on the unit drawing.
4. All lights, switches and outlets shall be wired to a fused or non-fused disconnect for a separate 120 volt external source.
5. Specified sections on schedule shall be equipped with a vapor-proof 23W Compact Fil Light.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer's instructions.
B. Coordinate with roofing contractor for curb installation and flashing.
C. Mount units on factory built roof mounting curb providing watertight enclosure to protect ductwork and utility services. Install roof mounting curb level.
D. Locate remote panels where indicated on drawings.

3.02 SYSTEM STARTUP

A. Provide factory authorized technicians to prepare and start equipment. Adjust for proper operation.
B. Factory authorized technicians shall prepare and submit a start up report for all units installed under this contract.

END OF SECTION
PART 1 GENERAL
CONVECTION HEATING AND COOLING UNITS

1.01 SECTION INCLUDES
A. Reheat Coil

1.02 REFERENCE STANDARDS

1.03 SUBMITTALS
A. Shop Drawings: Indicate coil fin height & length and overall height, length and depth, connection sizes & location, flange mounting dimensions, and direction of airflow.
B. Product Data.
   1. Certification - Acceptable coils are to be certified in accordance with ARI Standard 410 and bear the ARI label. Coils exceeding the scope of the manufacturer's certification and/or the range of the ARI's standard rating conditions will be considered provided the manufacturer is a current member of the ARI Air-Cooling and Air-Heating Coils certification programs and that the coils have been rated in accordance with ARI Standard 410. Manufacturer must be ISO 9002 certified.
   2. Identify fin, tube & casing material type and thickness.
   3. Show coil weight (shipping & operating).
   4. State air and water flow amounts with its associated pressure drops.
   5. Indicate entering & leaving air and water temperatures.

1.04 QUALIFICATIONS
A. Manufacturer: Company specializing in manufacturing water cooling and heating coils specified in this section must show a minimum five years experience and issues complete catalog data.

1.05 DELIVERY, STORAGE AND HANDLING
A. Deliver, store, protect and handle products to site.
B. Accept products on site on factory-installed shipping skids. Inspect for damage.
C. Store in a clean dry place and protect from weather and construction traffic. Handle carefully to avoid damage.

PART 2 PRODUCTS
2.01 AIR COILS
A. Acceptable Manufacturers:

B. GENERAL DESCRIPTION
   1. Furnish as shown on plans and as described in the specification, Daikin Applied Water Heating Coils.
   2. Coils to have extended surface, staggered tube, and plate fin design.

C. HEADERS
   1. Made of seamless copper tubing to assure compatibility with primary surface.
   2. Headers to have intruded tube holes to provide maximum brazing surface for tube to header joint, strength, and inherent flexibility. Header diameter should vary with fluid flow requirements.
   3. Vent and drain plugs shall be provided on the coil header.

D. CONNECTIONS
   1. Coil connection should be compatible with the piping to the coil to minimize chance of "galvanic action/electrolysis."
   2. Connections shall be a diameter adequate for specified gpm flow.
a. The connections are located to permit right hand mounting of the coil and assure equal pressure through all the circuits.

3. Connection and material type.
   a. Connection material to be carbon steel pipe. Connection type to be threaded.

4. Coils are circuited to provide maximum mean effective temperature difference for heat transfer rates.

5. Coils, greater than 2 rows, must be arranged for counter flow.

E. TESTING AND PRESSURE RATINGS
1. Completed coils are tested at a minimum of 315 PSIG air pressure while submerged in warm water.
2. Hydronic tests alone are not acceptable.
3. Standard coil construction is rated for 250 PSIG working pressure at 300 degrees F.

F. CAPACITY
1. Coil capacity shall be as outlined on the project schedule and confirmed with computer generated output.
2. Application.
   a. Heating.
3. Fluid Type.
   a. Water.

G. PRIMARY SURFACE
1. Tubes to be 5/8" O.D., staggered in direction of airflow, and must be on 3" tube centers.
2. Wall thickness to be .020" nominal copper and water pressure drop of coil selection adjusted to wall thickness specified.
3. Tubes to be mechanically expanded into fin collars to provide a continuous primary to secondary compression bond over entire coil length, assuring maximum heat transfer.
4. Coil Tube Type.

H. SECONDARY SURFACE
1. Plate style fins shall be corrugated for high capacity and structural strength.
   a. Fin thickness shall be .0075" copper.
2. The fins have to have collars to determine fin spacing per inch and support the heat transfer bond to primary surface. Tubing should not be visible between the fins.
   a. Fin Style to be a Hi-F fin type.

I. COIL TYPE & SERPENTINE
1. 5WB - Half Serpentine with rows on 3.00" tube centers.
2. Coils available from 12" to 54" fin height on 1.5" tube centers and on 3" increments.

J. CASINGS
1. Casing Style
   a. Contractor Coil with flanged casing.
2. Casing Material.
   a. Galvanized Steel.

PART 3 EXECUTION
3.01 INSTALLATION
A. Install in accordance with manufacturer's recommendations.

3.02 CLEANING
A. After construction is completed, clean exposed surfaces of units.
B. Vacuum clean coils and inside of units.
C. Touch-up marred or scratched surfaces of factory-finished cabinets using finish materials furnished by the manufacturer.
3.03 PROTECTION
   A. Provide finished cabinet units with protective covers during the balance of construction.

END OF SECTION
SECTION 26 05 01
MINOR ELECTRICAL DEMOLITION

PART 1 GENERAL
1.01 SECTION INCLUDES
A. Electrical demolition.

PART 2 PRODUCTS
2.01 MATERIALS AND EQUIPMENT
A. Materials and equipment for patching and extending work: As specified in individual sections.

PART 3 EXECUTION
3.01 EXAMINATION
A. Verify field measurements and circuiting arrangements are as shown on Drawings.
B. Verify that abandoned wiring and equipment serve only abandoned facilities.
C. Demolition drawings are based on casual field observation and existing record documents.
D. Report discrepancies to District before disturbing existing installation.
E. *Beginning of demolition means installer accepts existing conditions.*

3.02 PREPARATION
A. Disconnect electrical systems in walls, floors, and ceilings to be removed.
B. Coordinate utility service outages with utility company.
C. Provide temporary wiring and connections to maintain existing systems in service during construction. When work must be performed on energized equipment or circuits, use personnel experienced in such operations.
D. Existing Electrical Service: Maintain existing system in service until new system is complete and ready for service. Disable system only to make switchovers and connections. Minimize outage duration.
   1. Obtain permission from District at least 24 hours before partially or completely disabling system.
   2. Make temporary connections to maintain service in areas adjacent to work area.
E. Existing Fire Alarm System: Maintain existing system in service until new system is accepted. Disable system only to make switchovers and connections. Minimize outage duration.

3.03 DEMOLITION AND EXTENSION OF EXISTING ELECTRICAL WORK
A. Remove, relocate, and extend existing installations to accommodate new construction.
B. Remove abandoned wiring to source of supply.
C. Remove exposed abandoned conduit, including abandoned conduit above accessible ceiling finishes. Cut conduit flush with walls and floors, and patch surfaces.
D. Disconnect abandoned outlets and remove devices. Remove abandoned outlets if conduit servicing them is abandoned and removed. Provide blank cover for abandoned outlets that are not removed.
E. Disconnect and remove electrical devices and equipment serving utilization equipment that has been removed.
F. Repair adjacent construction and finishes damaged during demolition and extension work.
G. Maintain access to existing electrical installations that remain active. Modify installation or provide access panel as appropriate.
H. Extend existing installations using materials and methods compatible with existing electrical installations, or as specified.
3.04 CLEANING AND REPAIR

A. Clean and repair existing materials and equipment that remain or that are to be reused.

B. Panelboards: Clean exposed surfaces and check tightness of electrical connections. Replace damaged circuit breakers and provide closure plates for vacant positions. Provide typed circuit directory showing revised circuiting arrangement.

C. Luminaires: Remove existing luminaires for cleaning. Use mild detergent to clean all exterior and interior surfaces; rinse with clean water and wipe dry. Replace lamps, ballasts and broken electrical parts.

END OF SECTION
SECTION 26 05 10
ELECTRICAL GENERAL PROVISIONS

PART 1 GENERAL

1.01 SECTION INCLUDES
A. Furnish all labor, materials, apparatus, tools, equipment, transportation, temporary construction and special or occasional services as required to make a complete working electrical installation, as shown on the drawings or described in these specifications.

1.02 REFERENCES
A. Reference to codes, standards, specifications and recommendations of technical societies, trade organizations and governmental agencies shall mean the latest edition of such publications adopted and published prior to submittal of the bid proposed. Such codes or standards shall be considered a part of this specification as though fully repeated herein.
B. When codes, standards, regulations, etc., allow work of lesser quality or extent than is specified under this Division, nothing in said codes shall be construed or inferred as reducing the quality, requirements or extent of the drawings and specifications.
C. California Code of Regulations (CCR) Title 24, Part 3, Basic Electrical Requirements, State Building Standards Electrical Code
D. National Fire Protection Association (NFPA).
E. Equipment and materials specified under this Division shall conform to the following standards where applicable:
1. UL Underwriters’ Laboratories
2. ASTM American Society for Testing Materials
3. CMB Certified Ballast Manufacturers
4. IPCEA Insulated Power Cable Engineer Assoc.
5. NEMA National Electrical Manufacturer’s Assn.
6. ANSI American National Standards Institute
7. ETL Electrical Testing Laboratories
F. All base material shall be ASTM and/or ANSI standards.
G. All electrical apparatus furnished under this Section shall conform to National Electrical Manufacturers Association (NEMA) standards and the NEC and bear the Underwriters’ Laboratories (UL) label where such label is applicable.

1.03 SUBMITTALS
A. See Division 1 for submittal procedures.
B. Where items are noted as "or equal" a product of equal design, construction and performance will be considered. Contractor must submit all pertinent test data, catalog cuts and product information required to substantiate that the product is in fact equal. Refer to Division 1, General Requirement for additional requirements. Only one substitution will be considered for each product specified.
C. Submittals shall consist of detailed shop drawings, specifications, "catalog cuts" and data sheets containing physical and dimensioned information, performance data, electrical characteristics, material used in fabrication, material finish and shall clearly indicate those optional accessories which are included and those which are excluded. Furnish one reproducible and 4 prints of each shop drawing.

1.04 CUTTING, PAINTING AND PATCHING
A. Structural members shall in no case be drilled, bored or notched in such a manner that will impair their structural value. Cutting of holes, if required, shall be done with core drill and only with the approval of the Engineer.
B. Cutting and digging shall be under the direct supervision of the General Contractor. Include as necessary for the work in this section.
C. The contractor shall be responsible for returning any surface from which he has removed equipment or devices to the condition and finish of the adjacent surfaces.

1.05 SUPERVISION
A. Contractor shall personally or through an authorized and competent representative constantly supervise the work from beginning to completion and, within reason, keep the same workmen and foreman on the project throughout the project duration.

1.06 PROTECTION
A. Keep conduits, junction boxes, and outlet boxes, and other openings closed to prevent entry of foreign matter: cover fixtures, equipment, and apparatus and protect against dirt, paint, water, chemical, or mechanical damage, before and during construction period. Restore to original condition any fixture, apparatus, or equipment damaged prior to final acceptance, including restoration of damaged shop coats of paint, before final acceptance. Protect bright finished surfaces and similar items until in service. No rust or damage will be permitted.

1.07 EXAMINATION OF SITE
A. The Contractor shall visit the site and determine the locale, working conditions, conflicting utilities, and the conditions in which the electrical work will take place. No allowances will be made subsequently for any costs which may be incurred because of any error or omission due to failure to examine the site and to notify the Engineer of any discrepancies between drawings and specifications and actual site conditions. Schedule visits at least 1 week in advance with District's Maintenance staff.

1.08 ENVIRONMENTAL REQUIREMENTS
A. After other work such as sanding, painting etc. has been completed, clean lighting fixtures, panelboards, switchboards, and other electrical equipment to remove dust, dirt, and grease, or other marks, and leave work in clean condition.

1.09 VOLTAGE CHECK
A. At completion of job, check voltage at several points of utilization on the system which has been installed under this contract. During test, energize all loads installed. Measure 3-Phase voltages and note percentage differences. Submit report to Engineer. Include copy in O&M Manual.

1.10 TESTS
A. Perform tests as specified to prove installation is in accordance with contract requirements. Perform tests in the presence of the Engineer and furnish test equipment, facilities, and technical personnel required to perform tests. Tests shall be conducted during the construction period and at completion to determine conformity with applicable codes and with these Specifications. Tests, in addition to specific system test described elsewhere, shall include:
   1. Insulation Resistance: All 600 volt insulation shall be tested at 1,000 volts D.C for one minute on all feeder and branch circuit conductors including the neutral, and make a typed record of all readings to be included in the maintenance instructions. The direct current amperes shall be recorded at start and at one minute. The value shall be declining and not more than one microampere.
   2. Circuit Continuity: Test all feeder and branch circuits for continuity. Test all neutrals for improper ground.
B. Equipment Operations: Test motors for correct operation and rotation.
C. Product Failure: Any products which fail during the tests or are ruled unsatisfactory by the Engineer shall be replaced, repaired, or corrected as prescribed by the Engineer at the expense of the Contractor. Tests shall be performed after repairs, replacements, or corrections until satisfactory performance is demonstrated.
D. Miscellaneous: Include all test results in the maintenance manual. Cost, if any, for all tests shall be paid by the Contractor.

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ELECTRICAL GENERAL PROVISIONS

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1.11 DRAWINGS

A. Layout: General layout shown on the drawing shall be followed except where other work may conflict with the drawings.

B. Accuracy:
   1. Drawings for the work under this section are diagrammatic.
   2. Contractor shall verify lines, levels, and dimensions shown on the drawings and shall be responsible for the accuracy of the setting out of work and for its strict conformance with existing conditions at the site.
   3. Contractor shall insure reconnection of existing equipment and circuits affected by contract demolition whether or not reconnection is specifically shown on the contract documents.

1.12 PROJECT RECORD DRAWINGS

A. Refer to General Conditions for contractual requirements. Provide project record drawings as required by the General Provisions of the specifications and as required herein. Such drawings shall fully represent installed conditions including actual locations of outlets, true panelboard connections following phase balancing routines, correct conduit and wire sizing as well as routing, revised fixture schedule listing the manufacturer and products actually installed and revised panel schedule. All changes to drawings shall be made by qualified draftspersons to match existing linework and lettering as close as possible. When all the changes have been made to the trade drawings, contractor shall produce one (1) full size (E-Size) updated set of trade drawing(s) utilizing AutoCad 2008 or newer and supply one (1) set of Compact Discs (CD's) reflecting same.

1.13 MAINTENANCE AND OPERATING INSTRUCTIONS

A. Furnish to the Engineer four (4) hard back 3-ring binders containing all bulletins, operating and maintenance instructions and part lists and other pertinent information for each and every piece of equipment furnished under this specification. Include service telephone numbers. Each binder shall be indexed into sections and labeled for easy reference. Bulletins containing more information than the equipment concerned shall be properly stripped and assembled.

B. At the time of completion, a period of not less than eight hours shall be allotted by the Contractor for instruction of building operating and maintenance personnel in the use of all systems. All personnel shall be instructed at one time, the Contractor making all necessary arrangements with manufacturer's representative. The equipment manufacturer shall be requested to provide product literature and application guides for the user's reference. Costs, if any for the above services shall be paid by the Contractor.

1.14 WARRANTIES

A. Furnish to the Engineer four (4) hard back 3-ring binders containing all warranties of every piece of equipment furnished under this specification. Include terms and limitations of warranties, contact names, addresses, and telephone numbers of manufacturer. Each binder shall be indexed into sections and labeled for easy reference for each equipment warranty.

1.15 EXTRA MATERIALS

A. See Division 1 - Product Requirements, for additional provisions.

B. All special tools for proper operation and maintenance of the equipment provided under this Section shall be delivered to the District's representative.

PART 2 PRODUCTS - NOT USED

PART 3 EXECUTION

3.01 WORKMANSHIP

A. Preparation, handling, and installation shall be in accordance with manufacturer's written instructions and technical data particular to the product specified and/or accepted equal except as otherwise specified. Coordinate work and cooperate with others in furnishing and placing.
this work. Work to reviewed shop drawings for work done by others and to field measurements as necessary to properly fit the work.

B. Conform to the National Electrical Contractor's Association "Standard of Installation" for general installation practice.

3.02 INSTALLATION

A. Install in accordance with manufacturer's instructions.

END OF SECTION
SECTION 26 05 12
BASIC MATERIAL AND METHODS

PART 1 GENERAL
1.01 SECTION INCLUDES
   A. Conduit, raceways and fittings.
   B. Wires and Cables for 600 Volts and less.
   C. Wire connections.
   D. Wire devices.
   E. Outlet boxes.
   F. Pull and junction boxes.
   G. Disconnect Switches.
   H. Fuses.
   I. Supporting Devices.
   J. Identifying Devices.
   K. Grounding and Bonding

PART 2 PRODUCTS
2.01 CONDUIT, RACEWAYS AND FITTINGS
   A. Rigid Steel Conduit
      1. Rigid steel conduit shall be full weight, pipe size, finished inside and out by hot-dip galvanizing after fabrication, and shall conform with ANSI C80.1 and UL.
      2. Couplings shall be electroplated steel.
      3. Insulating Bushings: Threaded polypropylene or thermo-setting phenolic rated 150°C minimum.
      4. Insulated grounding Bushings: Threaded cast malleable iron body with insulated throat and steel "lay-in" ground lug with compression screw.
      5. Insulated Metallic Bushings: Threaded cast malleable iron body with plastic insulated throat rated 150°C.
      6. Running threads are not acceptable.
   B. Electrical Metallic Tubing (EMT):
      1. Conduit: Conduit shall be formed of cold rolled strip steel, and shall comply with ANSI C80.3 and UL requirements.
      2. Couplings: Electroplated steel, UL listed rain and concrete tight through 1-1/4" trade size. All EMT fittings shall be compression type.
      3. Connectors: Steel, gland compression type with insulated plastic throat, 150°C temperature rated. All EMT fittings shall be compression type.
   C. Liquid Tight Flexible Metal Conduit:
      1. Conduit: Conduit shall be fabricated in continuous lengths from galvanized steel strip, spirally wound. Flexible conduit, except where installed in concealed dry locations, shall be liquid tight with plastic jacket extruded over the outer zinc coating. No aluminum substitute will be accepted.
      2. Fittings: Connectors shall be the screw clamp on screw-in (Jake) variety with cast malleable iron bodies and threaded male hubs with insulated throat or insulated bushings. Set screw type connectors are not acceptable. Liquid tight fittings shall be of cadmium plated cast malleable iron, with insulated throat.
   D. Rigid Non-Metallic Conduit:
      1. Conduit and fittings shall be homogeneous plastic material free from visible cracks, holes or foreign inclusions. The conduit bore shall be smooth and free of blisters, nicks or other imperfections which could damage conductors or cables.

2.02 WIRING AND CABLES

A. Acceptable manufacturers: Southwire, or approved equal.
B. Conductor material: All wire and cable shall be insulated, stranded copper conductors. Soft drawn annealed copper wire 98% conductivity, bearing the UL label.
C. Minimum conductor size: AWG No. 12 for all power and lighting branch circuits. AWG No. 14 for all signal and control circuits.
D. Color Coding: System conductors shall be identified as to voltage and phase connections by means of color impregnated insulation or approved colored marking tape as follows:

E. For 120/240 volt, single phase, 3 wire system.
   1. Phase A - Black
   2. Phase B - Red
   3. Phase C - Orange for High Leg (208v to neutral)
   4. Neutral - White
   5. Ground - Green

F. For 120/208 volt, 3 phase, 4 wire systems.
   1. Phase A - Black
   2. Phase B - Red
   3. Phase C - Blue
   4. Neutral - White
   5. Ground - Green

G. For 277/480 Volt, 3 phase, 4 wire system
   1. Phase A - Brown
   2. Phase B - Orange
   3. Phase C - Yellow
   4. Neutral - Grey
   5. Ground - Green

H. Secondary Wire and Cable, 0 to 600 Volts;
   1. NEC Type THWN, or Type XHHW for feeders and branch circuits in wet or dry locations.
   2. NEC type THHN for branch circuits in dry locations.

2.03 WIRE CONNECTION

A. Wire Joints: Wires in sizes from #18 to #8 AWG, stranded conductor, with insulation rated 105 degrees C. or less shall be joined with electrical spring connectors of three part construction incorporating a non-restricted, zinc coated steel spring enclosed in a steel shell with an outer jacket of vinyl plastic with a flexible insulating skirt.
B. Mechanical Compression Connectors and Taps: Stranded conductors from #6 AWG to 750 Kcmil shall be joined or tapped using bolted pressure connectors having cast bronze compression bolts. Fittings shall be wide range-taking and designed to facilitate the making of parallel taps, tees, crosses or end-to-end connections. Split-bolt connectors will not be acceptable.
C. Fixture Connections: Splice fixture wire to circuit wiring with solderless connectors as specified above in paragraph A.
D. Terminating Lugs: Conductors from size No. 6 AWG to 750 Kcmil, copper, shall be terminated using tin plated hydraulically operated crimping tools and dies as stipulated by the lug manufacturer. Lugs shall be 3M "Scotchlok" series 30000, Burndy Type Ya-L series, or equal.
E. Splicing and Insulating Tape (600 volts and below): General purpose electrical tape shall be suitable for temperatures from minus 18 degrees C to 105 degrees C, shall be black, ultraviolet proof, self-extinguishing, 7 mil thick vinyl with a dielectric strength of 10,000 volts. Apply 4 layers half-lap with 2" over-lay on each conductor.
F. Insulating Putty (600 volts and below): Pads or rolls of non-corrosive, self-fusing, one eight inch thick rubber putty with PVC backing sheet. Putty shall be suitable for temperatures from minus 17.8 degrees C to 37.8 degrees C and shall have a dielectric strength of 570 volts/mil minimum.

G. Insulating Resin: Two Part liquid epoxy resin with resin and catalyst in pre measured, sealed mixing pouch. Resin shall have a set up time of approximately 30 minutes at 21.1 degrees C, and shall have thermal and dielectric properties equal to the insulation properties of the cables immersed in the resin.

H. Terminal Strip Connectors: Terminate wire in locking tongue style, pressure type, solderless lug where applicable.

2.04 WIRING DEVICES

A. Switches: Specification grade, flush mounting, quiet operating AC type, with toggle operator, heat resistant plastic housing and self grounding metal strap. Silver or silver alloy contact. Rated 20A at 120-277V and capable of full capacity on tungsten or fluorescent lamp load. Design for up to #10 wire. Use single pole, double pole, three-way, four-way, lighted, pilot, or keyed type, as indicated on drawings or required. Provide white color unless otherwise noted. Manufacturer: Leviton, Arrow Hart, or Hubbell.

B. Receptacles: Specification grade, flush mounting receptacles with nylon face. High grade brass allow triple wipe contacts. Provide 2 pole, 3 wire grounding type with a green colored brass hexagonal equipment grounding screw. Grounding shall be rivetless, single piece brass with no mechanical connections in the primary path between point of ground wire termination and ground blades. Use 20A rated receptacles, white in color, unless otherwise noted. Manufacturer: Leviton, Arrow Hart, or Hubbell.

1. Isolated Ground - Provide separate path to ground, with orange faceplate or triangle to indicate isolated ground
2. GFCI - Equipped with diagnostic indicator for miswiring.
3. Weatherproof - GFCI type, outdoor rated, with metal lockable while in use cover

C. Faceplates: Provide nylon cover faceplates for wall receptacles, outlets, and switches. Include thermal mounting screws that match plate and device color. Manufacturer: Leviton, Arrow Hart, or Hubbell.

2.05 OUTLET BOXES

A. Standard outlet boxes: Galvanized, die formed or drawn steel, knock-out type of size and configuration best suited to the application indicated on the plans. Minimum box size, 4 inch square by 1-1/2 inch deep, indoor use. FS cast boxes are required for outdoor use.

B. Cast Metal Outlet Boxes: FS/FD cast boxes are required for outdoor use. Malleable iron alloy with threaded hubs and mounting lugs as required. Boxes shall be furnished with cast cover plates of the same material as the box and neoprene cover gaskets. Thomas and Betts, Crouse-Hinds, Appleton or equal.

C. Conduit Outlet Bodies: Cadmium plated, cast iron alloy. Obround conduit outlet bodies with threaded conduit hubs and neoprene gasketed, cast iron covers. Outlet bodies shall be used to facilitate pulling of conductors or to make changes in conduit direction only. Splices are not permitted in conduit outlet bodies. Thomas and Betts, Crouse-Hinds Form 8 Condulets, Appleton form 35 Unilet, or equal.

2.06 PULL AND JUNCTION

A. Sheet Metal Boxes: Use standard outlet or concrete ring boxes wherever possible; otherwise use minimum 15 gauge get metal, NEMA 1 boxes, sized to code requirements with covers secured by cadmium plated machine screws located 6 inches on centers. Circle AW Products, Hoffman Engineering Co., or equal.

B. Cast Metal Boxes: Use standard cast malleable iron outlet or device boxes wherever possible; otherwise use cadmium plated, cast malleable iron junction boxes with bolt-on, interchangeable conduit hub plates with neoprene gaskets. Appleton FS/FD series; Crouse Hinds FS/FD series, or equal.
2.07 DISCONNECT SWITCHES
   A. All disconnect switches shall be heavy-duty type and have the number of poles, voltage rating, and horsepower rating as required by the motor or equipment. Disconnect switches shall be in enclosures to suit conditions, NEMA 3R for outdoor and NEMA 1 for indoor. Disconnect switches shall be fused unless otherwise noted on the drawings. As manufactured by: Square D - Class 3110, ITE, Siemens, or equal.

2.08 FUSES
   A. Dual Element, Time Delay, UL Class RK5. Rejection type. Size and Voltage as indicated on equipment. Bussman, Little Fuse, or approved equal.

2.09 ELECTRICAL SUPPORTING DEVICES
   A. Concrete Fasteners: Hilti Kwik Bolt TZ or equal, self drilling expansion type concrete anchor.
   B. Conduit Straps: Hot-dip galvanized, cast malleable iron, two hole type strap with cast clamp-backs and spacers as required. OZ/Gedney, Thomas & Betts, or equal.
   C. Construction Channel: 1-1/2 inch by 1-1/2 inch 12 gauge galvanized steel channel with 17/32 inch diameter bolt holes, 1-1/2 inch on center, in the base of the channel. Kindorf 905 series, Unistrut P-1000-HS or equal.
   D. Cable Ties and Clamps: Thomas and Betts Co. “Ty-Raps” Panduit “Pan-Ty” or equal one piece, nylon, reusable type lashing ties.
   E. Fasteners (General): Wood screws for fastening to wood. Machine screws for fastening to steel. Toggle bolts for fastening to hollow concrete block, gypsum board, or plaster walls. Expansion anchors for attachments to pre-poured concrete.

2.10 IDENTIFYING DEVICES
   A. Nameplates: Type NP: Engraved black bakelite, 1 inch by 3-1/2 inch, 1/8 inch high white letters, machine screw retained. For permanent identification of all switchboards, panelboards, circuit breakers in separate enclosures, motor starters, relays, time switches, disconnect switches and other cabinet-enclosed apparatus including terminal cabinets or match existing as closely as possible.
   B. Legend Plates: Type LP: Die-stamped metal legend plate with mounting hole and positioning key for attachment to panel mounted operators’ devices. Engraved paint-filled characters as specified.
   C. Wire & Terminal Markers: Self-adhering, pre-printed vinyl with self-laminating wrap around strip. Markers shall be legible after termination. Brady B191 series, Thomas & Betts WSL series or equal.
   D. Conductor Phase Markers: Thomas & Betts WCPHAS series or similar in addition to colored marking as specified under this section of the specifications.

2.11 GROUNDING AND BONDING
   A. Ground Rods
      1. Manufacturer: Blackburn, Erico, or approved Equal
      2. Size: 3/4" x 10' Ground Rods
   B. Grounding Electrode Conductor, 2/0 for foundation foots, and per NEC.
   C. Grounding Well - Christy Box, G5 Traffic Valve Box.

PART 3 EXECUTION
3.01 CONDUIT AND RACEWAY APPLICATIONS
   A. Rigid Steel Conduit: Use rigid steel conduit for the following locations or conditions:
      1. All exterior applications
      2. All conduits larger than 2" trade diameter.
      3. All conduits indoor below eight (8) feet above finished floor.
   B. Electrical Metallic Tubing (EMT): EMT is allowed for the following conditions:
1. Interior only and above eight (8) feet from finished floor.
2. Interior only and when entering a panel from above.

C. Liquidtight Flexible Metallic Conduit: Use Liquidtight for the following conditions:
1. In damp and wet locations for connections to motors, transformers, vibrating equipment and machinery.
2. Connections to all pump motors, flow switches, and similar devices.

D. Rigid Non-Metallic Conduit, Polyvinyl Chloride (PVC) Schedule 40:
1. Underground installation.

3.02 CONDUIT INSTALLATION

A. General
1. All conduit runs shown on the plans are sized based on the use of rigid steel conduit and THWN copper conductors. If conductor type is changed the contractor shall be responsible for resizing conduits to meet code. In no case is conduit to be sized smaller than 3/4" trade diameter.
2. Low voltage wiring shall be installed in conduit, minimum 3/4" trade diameter.
3. Conduits shall be tightly covered and well protected during construction using metallic bushings and bushing "pennies" to seal open ends.
4. In making joints in rigid steel conduit, ream conduit smooth after cutting and threading.
5. Clean any conduit in which moisture or any foreign matter has collected before pulling in conductors. Paint all field threaded joints to prevent corrosion.
6. In all empty conduits or ducts, install an 1100 pound tensile strength polyethylene pulling rope.
7. Conduit systems shall be electrically continuous throughout. Install code size, uninsulated, copper grounding conductors in all conduit runs, grounding conductor shall be bonded to conduit, equipment frames and properly grounded.

B. Layout:
1. All new conduits shall be concealed. Any field conditions that does not allow concealment of conduits shall be reviewed with the Engineer prior to rough-in.
2. Locations of conduit runs shall be planned in advance of the installation and coordinated with concrete work, plumbing and framing.
3. Where practical install conduits in groups in parallel vertical or horizontal runs and at elevations that avoid unnecessary off-sets.
4. Low voltage conduit shall be grouped separately and labelled every 10 ft interval as to system (i.e. fire, control, etc)
5. Exposed conduit shall be run parallel or at right angles to the centerlines of the columns and beams.
6. Conduits shall not be placed closer than 12 inches from a parallel hot water or steam line or three inches from lines crossing perpendicular to the runs.
7. In long runs of conduit, provide sufficient pull boxes per NEC inside buildings to facilitate pulling wires and cables. Support pull boxes from structure independent of conduit supports. These pull boxes are not shown on the plans.

C. Supports:
1. All raceway systems shall be secured to building structures using specified fasteners, clamps and hangers spaced according to Code.
2. Support single runs of conduit using two hole pipe straps. Where run horizontally on walls in damp or wet locations, install "clamp blocks" to space conduit off the surface.
3. Multiple conduit runs shall be supported using "trapeze" hangers fabricated from 3/8 inch diameter, threaded steel rods secured to building structures. Fasten conduit to construction channel with standard two hole pipe clamps. Provide lateral seismic bracing for hangers.
4. Installation
   a. Locate and install anchors, fasteners, and supports in accordance with NECA "Standard of Installation".

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1) Do not fasten supports to pipes, ducts, mechanical equipment, or conduit.
2) Do not drill or cut structural members.

b. Rigidly weld support members or use hexagon-head bolts to present neat appearance with adequate strength and rigidity. Use spring lock washers under all nuts.

c. Install surface-mounted cabinets and panelboards with minimum of four anchors.
d. In wet and damp locations use steel channel supports to stand cabinets and panelboards 1 inch off wall.
e. Use sheet metal channel to bridge studs above and below cabinets and panelboards recessed in hollow partitions.

D. Terminations and Joints:
1. Raceways shall be joined using specified couplings or transition couplings where dissimilar raceway systems are joined.
2. Rigid conduit connection to enclosures shall be made by Myers type grounding hubs only. EMT connections to enclosures shall be made with compression connector with grounding lock-nuts or bushings.
3. Conduit terminations exposed at weatherproof enclosures and cast outlet boxes shall be made watertight using appropriate connectors and hubs.
4. Install expansion couplings where any conduit crosses a building separation or expansion joint.
5. Install cable sealing bushings on all conduits originating outside the building walls and terminating in switchgear, cabinets or gutters inside the building. Install cable sealing bushings or caulk conduit terminations in all grade level or below grade exterior pull, junction or outlet boxes.

E. Penetations:
1. Furnish and install metal sleeves for all exposed interior conduit runs passing through concrete floors or walls. Following conduit installation, seal all penetrations using non-iron bearing, chloride free, non-shrinking, dry-pack, grouting compound.
2. Install specified watertight conduit entrance seals and membrane clamps at all below grade wall and floor penetrations. Conduits penetrating exterior building walls and building floor slab shall be insulated rigid steel.
3. Conduits penetrating rated walls, floors, etc. shall be fireproofed.

3.03 CABLE AND WIRE INSTALLATION

A. Examination
1. Verify that interior of building has been protected from weather.
2. Verify that mechanical work likely to damage wire and cable has been completed.
3. Verify that raceway installation is complete and supported.
4. Verify that field measurements are as indicated.

B. Preparation
1. In existing conduits that will be reused, pull out existing conductors.
2. Completely and thoroughly swab raceway before installing wire.
3. Use 50/50 solution of Simple Green. Use CO2 to blow water and soap into conduit - let soak to break up dried out pulling compounds, then pull conductors. Pull one conductor at a time if not pull all out together.

C. General:
1. Conductors shall not be in conduit until all work of any nature that may cause injury is completed. Care should be taken in pulling conductors that insulation is not damaged. U.L. approved non-petroleum base and insulating type pulling compound shall be used as needed.
2. All cables shall be installed and tested in accordance with manufacturer's requirements and warranty.
3. Block and tackle, power driven winch or other mechanical means shall not be used in pulling conductors of size smaller than AWG #1.
D. Splicing and Terminating:
1. All aspects of splicing and terminating shall be in accordance with cable manufacturer's published procedures.
2. Make up all splices in outlet boxes with connectors as specified herein with separate tails of correct color to be made up to splice. Provide at least six (6) inches of tails packed in box after splice is made up.
3. All wire and cable in panels, control centers and equipment enclosures shall be bundled and clamped.
4. Encapsulate splices in exterior outlet, junction and pull boxes using insulating resin kits. All splices for exterior equipment in pump rooms shall be made up watertight.
5. Insulate mechanical compression taps AWG # 1/0 and larger using pre-molded, snap-on insulating boots or specified conformable insulating putty overwrapped with two half-lapped layers of insulating tape.

E. Identification:
1. Securely tag all branch circuits, noting the purpose of each. Mark conductors with vinyl wrap-around markers. Where more than two conductors run through a single outlet, mark each circuit with the corresponding circuit number at the panelboard.
2. Color code conductors size #6 and larger using specified phase color markers and identification tags.
3. All terminal strips are to have each individual terminal identified with specified vinyl markers.
4. All identification shall be legible and readable after completion of installation.
5. Provide labeling for all switches and receptacle outlets. Self-adhering machine clear tape with black letters.

3.04 INSTALLATION:
A. Route wire and cable as required to meet project conditions.
1. Wire and cable routing indicated is approximate unless dimensioned.
2. Where wire and cable destination is indicated and routing is not shown, determine exact routing and lengths required.
3. Include wire and cable of lengths required to install connected devices within 10 ft of location shown.

B. Install wire and cable in accordance with the NECA "Standard of Installation."

C. Use wiring methods indicated.

D. Pull all conductors into raceway at same time.

E. Use suitable wire pulling lubricant for building wire 4 AWG and larger.

F. Protect exposed cable from damage.

G. Support cables above accessible ceiling, using spring metal clips or metal cable ties to support cables from structure or ceiling suspension system. Do not rest cable on ceiling panels.

H. Use suitable cable fittings and connectors.

I. Neatly train and lace wiring inside boxes, equipment, and panelboards.

J. Clean conductor surfaces before installing lugs and connectors.

K. Make splices, taps, and terminations to carry full ampacity of conductors with no perceptible temperature rise.

L. Terminate aluminum conductors with tin-plated aluminum-bodied compression connectors only. Fill with anti-oxidant compound before installing conductor.

M. Use suitable reducing connectors or mechanical connector adaptors for connecting aluminum conductors to copper conductors.

N. Use split bolt connectors for copper conductor splices and taps, 6 AWG and larger. Tape uninsulated conductors and connector with electrical tape to 150 percent of insulation rating of conductor.
Use solderless pressure connectors with insulating covers for copper conductor splices and taps, 8 AWG and smaller.

Use insulated spring wire connectors with plastic caps for copper conductor splices and taps, 10 AWG and smaller.

Trench and backfill for direct burial cable installation as specified in Underground Structure Section. Install warning tape along entire length of direct burial cable.

Identify and color code wire and cable. Identify each conductor with its circuit number or other designation indicated.

### 3.05 ELECTRICAL CONNECTIONS

A. Make electrical connections in accordance with equipment manufacturer's instructions.

B. Make conduit connections to equipment using flexible conduit. Use liquidtight flexible conduit with watertight connectors in damp or wet locations.

C. Connect heat producing equipment using wire and cable with insulation suitable for temperatures encountered.

D. Provide receptacle outlet to accommodate connection with attachment plug.

E. Provide cord and cap where field-supplied attachment plug is required.

F. Install suitable strain-relief clamps and fittings for cord connections at outlet boxes and equipment connection boxes.

G. Install disconnect switches, controllers, control stations, and control devices to complete equipment wiring requirements.

H. Install terminal block jumpers to complete equipment wiring requirements.

I. Install interconnecting conduit and wiring between devices and equipment to complete equipment wiring requirements.

### 3.06 INSTALLATION OF BOXES

A. General:
   1. Leave no un-used openings in any box. Install close-up plugs as required to seal openings.
   2. Exposed outlet boxes and boxes in damp or wet locations shall be cast metal with gasketed cast metal cover plates.

B. Box Layout:
   1. Outlet boxes shall be installed at the locations and elevations shown on the drawings or specified herein. Make adjustments to locations as required by structural conditions and to suit coordination requirements of other trades.
   2. Install junction or pullboxes where required to limit bends in conduit runs to not more than 360 degrees or where pulling tension achieved would exceed the maximum allowable for the cable to be installed. Consult wire and cable manufacturer.

### 3.07 INSTALLATION OF WIRING DEVICES

A. General
   1. Install all devices flushmounted unless otherwise noted on the drawings. Comply with layout drawings for general locations. Consult Engineer or District's Representative for locations that have conflict with other devices or manner not suitable for installation. Avoid placing devices behind open doors.
   2. Align devices horizontally and vertically. Device plates shall be aligned vertically with tolerance of 1/16". All four edges of device plates shall be in contact with the wall surface.
   3. Mounting height as indicated on the drawings and according to ADA requirements.
   4. Install device plates on all outlet boxes. Provide blank plates for all empty, spare, and boxes for future use.
   5. Securely fasten devices into boxes and attach appropriate cover plates.
6. Caulk around edges or outdoor device plates and boxes when rough wall surfaces prevent raintight seal. Use caulking materials approved by Engineer. Fireproof around opening of devices located or penetrating firerated construction assemblies.

7. Fireproof around opening of devices located or penetrating firerated construction assemblies.

B. Switches
1. Where switches are indicated to be installed near doors, corner walls, etc. mount not less than 2 inches and not more than 18" from trim. Verify exact location with Architect or Engineer prior to rough-in.

2. Coordinate the location of switches to insure locations at the strike side of doors.

3. Furnish and install engraved legend of each switch that controls exhaust fans, motors, equipment systems, etc. not located within sight of the controlling switch.

4. Ganging of Switches - provide barriers for switches of difference phases and voltages. Otherwise switches shall be gauged in one faceplate.

C. Receptacles
1. Mount receptacles vertically with U-shaped ground position on bottom.

2. Do not combine GFCI protected circuits with other circuits in the same raceway. Limit number of GFI protect circuits in any one raceway to a maximum of one (1) circuit.

D. Identification
1. Label all outlets and switches. Mark each wiring device where circuits and panel supply is derived from.

2. All identification shall be legible and readable after completion of installation.

3.08 INSTALLATION OF FUSES AND DISCONNECT SWITCHES

A. Fuses shall be installed where noted on plans. Sizes are based on design data provided by equipment mfg. Listed or labeled equipment must be in accordance with instructions included in the listing or labeling. Be sure to observe maximum branch circuit fuse size labels.

B. Disconnect switches shall be mounted on the equipment, where possible. Coordinate with mechanical contractor to ensure switches are not mounted on a removable access panel.

C. Label each disconnect fuse with equipment tag as indicated in the single line diagram, or as directed.

3.09 ELECTRICAL EQUIPMENT GROUNDING

A. Ground non-current carrying metal parts of electrical equipment enclosures, frames, conductor raceways or cable trays to provide a low impedance path for line-to-ground fault current and to bond all non-current carrying metal parts together. Install a ground conductor in each raceway system in addition to conductors shown. Equipment ground conductor shall be electrically and mechanically continuous from the electrical circuit source to the equipment to be grounded. Size ground conductors per NEC 250 unless larger conductors are shown on the drawings.

B. Grounding conductors shall be identified with green insulation, except where a bare ground conductor is specified. Where green insulation is not available, on larger sizes, black insulation shall be used and suitably identified with green tape at each junction box or device enclosure.

C. Install metal raceway couplings, fittings and terminations secure and tight to insure good ground continuity. Provide insulated grounding bushing and bonding jumper where metal raceway is not directly attached to equipment metal enclosure and at concentric knock-outs.

D. Motors shall be connected to equipment ground conductors with a conduit grounding bushing and with a bolted solderless lug connection on the metal frame.

E. Conduit terminating in concentric knockouts at panelboards, cabinets and gutters shall have insulated grounding bushings and bonding jumpers installed interconnecting all such conduits and the panelboard cabinet, gutter, etc.

F. Performance:
1. Measure the resistance to ground of each ground rod before connection to the other ground rods. The resistance shall not exceed 25 ohms.
a. A single electrode which does not have a resistance to ground of 25 ohms or less shall be augmented by additional electrode(s).

2. Measure the resistance to ground of the total ground system with all connections completed. The resistance shall not exceed 2 ohms for primary services or 5 ohms for secondary services.

3. Tests of the resistance to ground shall be made using either the three point method or the fall-of-potential method.

4. Perform a continuity check from equipment ground bus bars and ground lugs to the ground system.

3.10 BONDING

A. Bonding shall be provided to assure electrical continuity and the capacity to conduct safely any fault current likely to be imposed.

B. Bonding shall be in accordance with NEC Article 250, Part V.

3.11 INSTALLATION

A. Install in accordance with manufacturer's instructions.

END OF SECTION
SECTION 26 05 26
GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 GENERAL
1.01 SECTION INCLUDES
A. Grounding and bonding requirements.
B. Conductors for grounding and bonding.
C. Connectors for grounding and bonding.
D. Grounding and bonding components for 600V and below include:
   1. Metal underground water pipe.
   2. Metal frame of the building.
   3. Rod electrodes.
   4. Grounding Electrode Conductors
   5. Equipment grounding conductors
   6. Bonding Conductors
E. Grounding and bonding components for 1kV systems and above include:
   1. Metal frame of the building.
   2. Rod electrodes.
   3. Grounding Electrode Conductors
   4. Grounding Well

1.02 REFERENCE STANDARDS
A. NECA 1 - Standard for Good Workmanship in Electrical Construction; National Electrical Contractors Association; 2010.
B. NFPA 70 - National Electrical Code; National Fire Protection Association; Most Recent Edition
   Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
C. UL 467 - Grounding and Bonding Equipment; Current Edition, Including All Revisions.

1.03 PERFORMANCE REQUIREMENTS
A. Grounding System Resistance: 5 ohms. Switching and Substations.

1.04 SUBMITTALS
A. See Section 01 30 00 - Administrative Requirements for submittals procedures.
B. Product Data: Provide for grounding electrodes and connections.
C. Test Reports: Indicate overall resistance to ground and resistance of each electrode.
D. Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.
E. Project Record Documents: Record actual locations of components and grounding electrodes.
F. Certificate of Compliance: Indicate approval of installation by authority having jurisdiction.

1.05 QUALITY ASSURANCE
A. Conform to requirements of NFPA 70.

PART 2 PRODUCTS
2.01 GROUNDING AND BONDING REQUIREMENTS
A. Do not use products for applications other than as permitted by NFPA 70 and product listing.
B. Unless specifically indicated to be excluded, provide all required components, conductors, connectors, conduit, boxes, fittings, supports, accessories, etc. as necessary for a complete grounding and bonding system.
C. Where conductor size is not indicated, size to comply with NFPA 70 but not less than applicable minimum size requirements specified.

2.02 GROUNDING AND BONDING COMPONENTS

A. General Requirements:
   1. Provide products listed, classified, and labeled by Underwriter's Laboratories Inc. (UL) or testing firm acceptable to authority having jurisdiction as suitable for the purpose indicated.
   2. Provide products listed and labeled as complying with UL 467 where applicable.

B. Conductors for Grounding and Bonding, in addition to requirements of Section 26 05 19:
   1. Use insulated copper conductors unless otherwise indicated.
      a. Exceptions:
         1) Use bare copper conductors where installed underground in direct contact with earth.
         2) Use bare copper conductors where directly encased in concrete (not in raceway).

C. Connectors for Grounding and Bonding:
   1. Description: Connectors appropriate for the application and suitable for the conductors and items to be connected; listed and labeled as complying with UL 467.
   2. Unless otherwise indicated, use exothermic welded connections for underground, concealed and other inaccessible connections.
   3. Unless otherwise indicated, use mechanical connectors, compression connectors, or exothermic welded connections for accessible connections.

D. Manufacturers: Cooper Power Systems, CadWeld, Erico, or approved equal.

E. Rod Electrodes: Copper.
   2. Length: 10 feet.

2.03 CONNECTORS AND ACCESSORIES

A. All electrical connections should be welded with the CADWELD copper-based exothermic welding process.

B. Exothermic Connections: (ERICO Cadweld)
   1. Cable to Ground Rod: Type NC
   2. Cable to Cable: Type XA, TA, PT
   3. Cable to Building Steel: Type DF (Column Bonding Bar), VV
   4. Cable to Rebar: Type RD, RC
   5. Cable to Equipment: Type LA, NEMA Lugs Connections
   6. Cable to Steel Pipes: Type HA
   7. Cable to Metallic Conduit: Pipe Clamp with Flexible Grounding Braids and Lug Connection

C. Grounding Electrode Conductor: Bare, stranded copper. Size as per drawings. Minimum size to meet NFPA 70 requirements.

D. Grounding Well:
   1. Well Box: Christy G3 Traffic Valve Box with hold down bolts

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that work likely to damage grounding and bonding system components has been completed.

B. Verify that field measurements are as shown on the drawings.

C. Verify that conditions are satisfactory for installation prior to starting work.

D. Verify existing conditions and resistivity prior to beginning work.

E. Verify that final backfill and compaction has been completed before driving rod electrodes.
3.02 INSTALLATION

A. Install products in accordance with manufacturer’s instructions.
B. Install grounding and bonding system components in a neat and workmanlike manner in accordance with NECA 1.
C. Make grounding and bonding connections using specified connectors.
   1. Remove appropriate amount of conductor insulation for making connections without cutting, nicking or damaging conductors. Do not remove conductor strands to facilitate insertion into connector.
   2. Remove nonconductive paint, enamel, or similar coating at threads, contact points, and contact surfaces.
   3. Exothermic Welds: Make connections using molds and weld material suitable for the items to be connected in accordance with manufacturer’s recommendations.
   4. Mechanical Connectors: Secure connections according to manufacturer’s recommended torque settings.
   5. Compression Connectors: Secure connections using manufacturer’s recommended tools and dies.
D. Identify grounding and bonding system components in accordance with Section 26 05 53.
E. Provide grounding well at power transformer, main switchboard, and at rod locations where indicated. Install well pipe top flush with finished grade.
F. Install 2/0 AWG bare copper wire in foundation footing.
G. For distribution transformers located away from main service entrance, provide and connect to grounding electrode conductor to a ground rod and building steel.
H. Provide isolated grounding conductor for specified circuits.
I. Equipment Grounding Conductor: Provide separate, insulated conductor within each feeder and branch circuit raceway. Terminate each end on suitable lug, bus, or bushing.
J. Ground all non-current carrying hardwares and metals. Include racks, supports, mounting hardwares, cable metallic shield, ladder, underfloor raceways, metal siding, metallic conduits, etc. Bond to grounding electrode.
K. Provide ground connection at all signal and data enclosures, lines, and data/telcom room.
L. Interface with site grounding system installed under Section 33 79 00.
M. Interface with lightning protection system installed under Section 26 41 13.

3.03 FIELD QUALITY CONTROL

A. District will provide field inspection in accordance with Section 01 40 00.
B. Perform inspection, testing, and adjusting in accordance with Section 01 40 00.
C. Perform inspections and tests listed in NETA STD ATS.
D. Perform ground electrode resistance tests under normally dry conditions. Precipitation within the previous 48 hours does not constitute normally dry conditions.
E. Investigate and correct deficiencies where measured ground resistances do not comply with specified requirements.

END OF SECTION
SECTION 26 05 29
HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 GENERAL
1.01 SECTION INCLUDES
A. Support and attachment components for equipment, conduit, cable, boxes, and other electrical work.

PART 2 PRODUCTS
2.01 SUPPORT AND ATTACHMENT COMPONENTS
A. General Requirements:
1. Provide all required hangers, supports, anchors, fasteners, fittings, accessories, and hardware as necessary for the complete installation of electrical work.
2. Provide products listed, classified, and labeled by Underwriter's Laboratories Inc. (UL) or testing firm acceptable to authority having jurisdiction as suitable for the purpose indicated, where applicable.
3. Where support and attachment component types and sizes are not indicated, select in accordance with manufacturer's application criteria as required for the load to be supported with a minimum safety factor of (2) time the maximum allowable tension loads as provided in the ICC-ES report. Include consideration for vibration, equipment operation, and shock loads where applicable.
4. Do not use products for applications other than as permitted by NFPA 70 and product listing.
5. Steel Components: Use corrosion resistant materials suitable for the environment where installed.
   a. Zinc-Plated Steel: Electroplated in accordance with ASTM B633.
   b. Galvanized Steel: Hot-dip galvanized after fabrication in accordance with ASTM A123/A123M or ASTM A153/A153M.
B. Conduit and Cable Supports: Straps, clamps, etc. suitable for the conduit or cable to be supported.
   1. Conduit Straps: One-hole or two-hole type; steel or malleable iron.
   2. Conduit Clamps: Bolted type unless otherwise indicated.
C. Outlet Box Supports: Hangers, brackets, etc. suitable for the boxes to be supported.
D. Metal Channel (Strut) Framing Systems: Factory-fabricated continuous-slot metal channel (strut) and associated fittings, accessories, and hardware required for field-assembly of supports.
E. Hanger Rods: Threaded zinc-plated steel unless otherwise indicated.
F. Anchors and Fasteners:
   1. Unless otherwise indicated and where not otherwise restricted, use the anchor and fastener types indicated for the specified applications.

2.02 MANUFACTURERS
A. HILTI; Model HILTI KWIK BOLT TZ: www.hilti.com.
   1. Do not use powder-actuated anchors, spring clips, or beam clamps.
   2. Obtain permission from Engineer before using powder-actuated anchors.
   3. Concrete Structural Elements: Use precast inserts, expansion anchors, powder-actuated anchors, or preset inserts.
   4. Concrete Surfaces: Use self-drilling anchors or expansion anchors.
   5. Hollow Masonry, Plaster, and Gypsum Board Partitions: Use toggle bolts or hollow wall fasteners.
   7. Sheet Metal: Use sheet metal screws.
B. Formed Steel Channel:
   1. Product: HS manufactured by HILTI, or approved equal.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install products in accordance with manufacturer’s instructions.

B. Install support and attachment components in a neat and workmanlike manner in accordance with NECA 1.

C. Provide independent support from building structure. Do not provide support from piping, ductwork, or other systems.

D. Unless specifically indicated or approved by Engineer, do not provide support from suspended ceiling support system or ceiling grid.

E. Unless specifically indicated or approved by Engineer, do not provide support from roof deck.

F. Do not penetrate or otherwise notch or cut structural members without approval of Structural Engineer.

G. Equipment Support and Attachment:
   1. Use metal fabricated supports or supports assembled from metal channel (strut) to support equipment as required.
   2. Use metal channel (strut) secured to studs to support equipment surface-mounted on hollow stud walls when wall strength is not sufficient to resist pull-out.
   3. Use metal channel (strut) to support surface-mounted equipment in wet or damp locations to provide space between equipment and mounting surface.
   4. Securely fasten floor-mounted equipment. Do not install equipment such that it relies on its own weight for support.

H. Secure fasteners according to manufacturer’s recommended torque settings. See M-5.3.

I. Remove temporary supports.

END OF SECTION
PART 1 GENERAL

1.01 SECTION INCLUDES
A. Performance requirements for overcurrent protective devices.
B. Arc flash hazard study.

1.02 SCOPE OF STUDIES
A. Arc Flash Study: The study shall include all new electrical distribution equipment shown on the single line diagram. This includes all switchgear, switchboards, panelboards, motor control centers, ATS's, and transformers. The ARC Flash Hazard Analysis shall be as per NFPA 70E.
B. Studies shall be performed by a California, registered professional electrical engineer skilled in performing power system studies.

1.03 SUBMITTALS
A. Study Report:
   1. Submit arc flash hazard study and with a list of arc flash warning labels at least 30 days prior to energizing the electrical equipment.
      a. Evaluation of product data submittals by Engineer will not commence until acceptable preliminary studies in sufficient detail to ensure that device selection will be adequate have been submitted.
   B. Study Report: Submit arc flash hazard study and with a list of arc flash warning labels at least 30 days prior to energizing the electrical equipment.

1.04 ARC FLASH STUDY
A. Provide an Arc Flash Hazard Study for all new electrical distribution system shown on the single line drawings. The intent of the Arc Flash Hazard Study is to determine hazards that exist at each major piece of electrical equipment shown on the single line drawing. This includes switchgear, switchboards, panelboards, motor control centers, PDUs, UPS, ATS's, and transformers. The study shall include creation of Arc Flash Hazard Warning Labels.
B. The arc flash hazard study shall include the electrical distribution system equipment shown on the single line drawing. Use the data from the Fault/Coordination Study to perform the Arc Flash Study. The arc flash hazard study shall consider operation during normal conditions, alternate operations, emergency power conditions, and other operations that could result in maximum arc flash hazard.
C. Arc flash hazard study shall be performed in accordance with NFPA - 70E, NEC 110.16, and IEEE 1584. Study shall include the following:
   1. Indicate arc flash boundaries.
   2. Incident energies.
   3. PPE (Personal Protective Equipment) requirements.
   4. Shock hazard voltage level.
   5. Approach distances; limited, restricted, and prohibited.
D. Produce an Arc Flash Warning label stating "DANGER, ARC FLASH HAZARD" and shall list the above items. Also include the bus name and voltage. Labels shall be printed in color on 3 inch x 5 inch, self adhesive backed Avery or DuraLabel labels. Electrical contractor shall furnish install the labels based on the study.
E. Produce an Arc Flash Evaluation Summary Sheet listing the following additional items:
   1. Bus name.
   2. Upstream Protective Device Name, Type, and Settings.
   5. Protective Device Bolted Fault Current.

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9. Equipment Type.
11. Arc Flash Boundary.
12. Working Distance.
13. Incident Energy.
14. Required Protective Fire Rated Clothing Type and Class.

PART 3 EXECUTION

2.01 ARC FLASH TRAINING

A. The testing agency shall train personnel of potential arc flash hazards associated with working on energized equipment (minimum 4 hours). Maintenance procedures in accordance with the requirements on NFPA 70E, Standard for Electrical Safety Requirements for Employee Workplaces, shall be provided by the testing company.

END OF SECTION
PART 1 - GENERAL

1.01 OVERVIEW

A. The purpose of these specifications is to assure that all tested electrical equipment and systems are operational and within applicable standards and manufacturer's tolerances and that the equipment and systems are installed in accordance with design specifications.

B. The work specified in these specifications may involve hazardous voltages, materials, operations, and equipment. These specifications do not purport to address all of the safety problems associated with their use. It is the responsibility of the independent testing agency to review all applicable regulatory limitations prior to the use of these specifications.

C. Perform the visual inspections, manual operations and tests on systems and equipment as described in Part 3, "Execution".

D. Tests shall be performed and documented by an independent testing agency.

E. Perform these tests in addition to other electrical tests delineated in other Sections.

1.02 REFERENCES

A. All inspections and field tests shall be in accordance with the latest edition of the following codes, standards, and specifications except as provided otherwise herein.

1. American National Standards Institute - ANSI
3. Institute of Electrical and Electronic Engineers - IEEE
4. Insulated Cable Engineers Association - ICEA
5. InterNational Electrical Testing Association - NETA
6. National Electrical Manufacturer's Association - NEMA
7. National Fire Protection Association - NFPA
8. Occupational Safety and Health Administration - OSHA
9. State and local codes and ordinances
10. Underwriters Laboratories, Inc. - UL

1.03 SUBMITTAL

A. The testing organization shall submit appropriate documentation to demonstrate that it satisfactorily complies with the following. An organization having a "Full Membership" classification issued by the InterNational Electrical Testing Association meets this criteria.

1. The testing organization shall be an independent, third party, testing organization which can function as an unbiased testing authority, professionally independent of the manufacturers, suppliers, and installers of equipment or systems evaluated by the testing organization.
2. The testing organization shall be regularly engaged in the testing of electrical equipment devices, installations, and systems.

B. The testing organization shall utilize technicians who are regularly employed for testing services.

C. Each on-site crew leader shall hold a current registered certification in electrical testing applicable to each type of apparatus to be inspected or tested. The certification in electrical testing shall be issued by an independent, nationally-recognized, technician certification agency. The following entities shall qualify as independent, nationally-recognized, technician certification agencies:

1. InterNational Electrical Testing Association (NETA)
2. Accepted certifications:
3. Certified Technician/Level III
4. Certified Senior Technician/Level IV
1.04 TEST REPORTS
   A. Provide written test reports, signed and dated, for all tests prior to acceptance of the tested equipment by the Owner. Test reports on megger, dielectric absorption and high potential tests shall include the ambient temperature and relative humidity existing at the time of the tests.

PART 2 - PART 2 -PRODUCTS (NOT APPLICABLE)

PART 3 - EXECUTION

3.01 VISUAL INSPECTIONS
   A. Prior to any testing, perform visual inspections to verify the following:
      1. The equipment is completely and properly installed
      2. The equipment is free from damage and defects
      3. Shipping blocks and restraints have been removed
      4. Electrical terminations have been properly tightened
      5. The equipment has been properly aligned
      6. The equipment has been properly lubricated
      7. The ventilation louvers are open and unobstructed
      8. The equipment is ready to be tested

3.02 MANUAL OPERATION
   A. Prior to any testing, mechanical devices shall be exercised or rotated manually to verify that they operate properly and freely.

3.03 PRIMARY CABLE TESTS
   A. Perform a continuity test, 2,500-volt DC megger test, AC high potential test, and a second 2,500-volt DC megger test on primary cables. The high potential test shall be performed at 45kV for new cable installations, and at 30kV when new cable has been spliced to existing cable.

3.04 POWER CABLE TESTS
   A. Perform a continuity check and a 1,000 volt DC megger test on 600 volt power cables No. 4 AWG and larger.
      1. The megger test shall be performed between each pair of conductors and from each conductor to ground.
      2. The megger test shall be performed for 15 seconds or until the insulation resistance value stabilizes.
      3. The insulation resistance between conductors and from each conductor to ground shall be 100 megohms minimum in one minute or less. In addition, the lowest insulation resistance value shall not differ from the highest value by more than 20 percent.

3.05 CONTROL CABLE TESTS
   A. Perform a continuity check on control and instrumentation wiring.

3.06 SECONDARY SWITCHGEAR AND SWITCHBOARD TESTS
   A. Perform a continuity check and 1,000 volt DC megger test on buses, and on main and feeder breakers.
   B. Perform a primary current injection test and a 'Ducter' (contact resistance) test on main breakers.
   C. Perform a 1,000-volt DC megger test and a turns-ratio test on CT's and PT's.
   D. Calibrate the metering.

3.07 SERVICE, DISTRIBUTION AND MOTOR CONTROL EQUIPMENT TESTS
   A. Perform a 1,000-volt megger test on buses, motor starters and disconnect switches. This test may be combined with the feeder cable megger test by testing the devices and terminated cables together.
   B. Perform a continuity check on motor control circuits and control panel internal wiring.

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C. Perform an operational test on the controls.
D. Perform a continuity check and a 1,000-volt DC megger test on 3 phase distribution and isolation transformers.

3.08 MOTOR TESTS
A. Perform a 1,000-volt megger test on 460 volt, 3 phase motors, and a 500 volt megger test on 200 volt, 3 phase motors.
B. "Bump" motors to verify proper direction of rotation.
C. Run motors and check for vibration.

3.09 GROUNDING TESTS
A. Measure the resistance to ground of each ground rod before connection to the other ground rods. The resistance shall not exceed 25 ohms.
   1. A single electrode which does not have a resistance to ground of 25 ohms or less shall be augmented by additional electrode(s).
B. Measure the resistance to ground of the total ground system with all connections completed. The resistance shall not exceed 2 ohms for primary services or 5 ohms for secondary services.
C. Tests of the resistance to ground shall be made using either the three point method or the fall-of-potential method.
D. Perform a continuity check from equipment ground bus bars and ground lugs to the ground system.

END OF SECTION