SPECIFICATIONS

for

C-1129 PAC BOILER REPLACEMENT
C-1130 PAC CHILLER REPLACEMENT
C-1131 AT PACKAGED UNIT REPLACEMENT
D-1044 CAMPUS-WIDE EMS UPGRADES
D-4017 MECHANICAL EQUIPMENT RETROFIT
P-4022 AHU REPLACEMENT

CONTRA COSTA COMMUNITY COLLEGE DISTRICT
Martinez, California

Gayner Engineers
1133 Post Street
San Francisco, CA 94109-5504

May 22, 2018
**TABLE OF CONTENTS**

**LIST OF DRAWINGS**

DIVISION 1 (NOT USED)

“The Agreement for Mechanical and Controls Design-Build Project” applies to this Section.

DIVISION 5

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>054000</td>
<td>Cold-Formed Metal Framing</td>
<td>6</td>
</tr>
<tr>
<td>055000</td>
<td>Metal Fabrications</td>
<td>10</td>
</tr>
</tbody>
</table>

DIVISION 7

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>075113</td>
<td>Built-Up Asphalt Roofing</td>
<td>11</td>
</tr>
<tr>
<td>076200</td>
<td>Sheet Metal Flashing and Trim</td>
<td>6</td>
</tr>
</tbody>
</table>

DIVISION 8

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>081214</td>
<td>Standard Steel Frames</td>
<td>6</td>
</tr>
<tr>
<td>081314</td>
<td>Standard Steel Doors</td>
<td>4</td>
</tr>
</tbody>
</table>

DIVISION 9

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>092116</td>
<td>Gypsum Board Assemblies</td>
<td>10</td>
</tr>
<tr>
<td>092400</td>
<td>Cement Plastering</td>
<td>6</td>
</tr>
<tr>
<td>099000</td>
<td>Painting and Coating</td>
<td>11</td>
</tr>
</tbody>
</table>

DIVISION 22

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>220500</td>
<td>Common Work Results for Plumbing</td>
<td>7</td>
</tr>
<tr>
<td>221000</td>
<td>Plumbing Piping</td>
<td>9</td>
</tr>
</tbody>
</table>

DIVISION 23

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>230000</td>
<td>Design Build Requirements</td>
<td>13</td>
</tr>
<tr>
<td>230500</td>
<td>Common Results for HVAC</td>
<td>16</td>
</tr>
<tr>
<td>230548</td>
<td>Vibration and Seismic Controls for HVAC System</td>
<td>16</td>
</tr>
<tr>
<td>230553</td>
<td>Identification for HVAC Piping and Equipment</td>
<td>9</td>
</tr>
<tr>
<td>230593</td>
<td>Testing Adjusting and Balancing for HVAC</td>
<td>17</td>
</tr>
<tr>
<td>230713</td>
<td>Ductwork Insulation</td>
<td>5</td>
</tr>
<tr>
<td>230716</td>
<td>HVAC Equipment Insulation</td>
<td>5</td>
</tr>
</tbody>
</table>
Contra Costa Community College District
Mechanical and Controls Design-Build Project

C-1129 PAC Boiler Replacement
C-1130 PAC Chiller Replacement
C-1131 AT Packaged Unit Replacement

APPENDIX A

APPENDIX B

DIVISION 2

Section 230719 HVAC Piping Insulation.................................................................15
Section 230800 Commissioning of HVAC System...............................................7
Section 232023 HVAC Pumps..............................................................................3
Section 232113 Hydronic Piping........................................................................13
Section 232120 Hydronic Specialties.................................................................8
Section 232500 HVAC Water Treatment............................................................4
Section 232923 Variable Frequency Drives.......................................................8
Section 233113 Metal Ducts.............................................................................14
Section 233113.19 Metal Duct Fitting.................................................................8
Section 233416 Centrifugal HVAC Fans.............................................................6
Section 234000 HVAC Air Cleaning Devices....................................................5
Section 235100 Breachings, Chimneys, and Stacks.........................................5
Section 235212 General Motor Requirements for HVAC and Steam
Generation Equipment....................................................................................7
Section 235225 Stainless Steel Fire Tube Condensing Boilers.........................12
Section 236400 Packaged Air Cooled Chiller – 60 Ton and Smaller..............12
Section 236403 Packaged Air Cooled Chiller – Larger than 60 Ton
(Scroll Compressor).....................................................................................10
Section 236406 Packaged Water Cooled Chiller (VFD Driven Screw)...........15
Section 236500 Induced Draft Cooling Tower................................................7
Section 237300 Custom Air Handling Units....................................................11
Section 237305 Air Handling Units.................................................................7
Section 238102 Package Rooftop AC Units and Heat Pumps...........................18
Section 238216 Air Coils...............................................................................13

DIVISION 25

Section 250000 Building Automation System..............................................184

DIVISION 26

Section 260126 Field Test and Operational Test ..........................................4
Section 260500 Common Work Results for Electrical.................................23
Section 260502 Basic Materials and Methods...............................................18
Section 260529 Hangers Supports Anchors and Seismic Restraints for
Electrical Systems.......................................................................................7
Section 262416 Panelboards.................................................................13
Section 262913 Low-Voltage Motor Controllers........................................6

APPENDIX A – Field Survey Notes

APPENDIX B – Existing Equipment Information

End of Table of Contents
**LIST OF DRAWINGS**

<table>
<thead>
<tr>
<th>Sheet No.</th>
<th>Drawing Title</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>G0.01</td>
<td>Cover Sheet</td>
<td>05/22/18</td>
</tr>
<tr>
<td>G0.02</td>
<td>Drawing Index and Project Overview</td>
<td>05/22/18</td>
</tr>
<tr>
<td>CC-M0.1</td>
<td>CCC Campus Plan</td>
<td>05/22/18</td>
</tr>
<tr>
<td>CC28-M1.1</td>
<td>Bldg 28 Automotive Technology – Field Survey Info and Mechanical Schedules</td>
<td>05/22/18</td>
</tr>
<tr>
<td>CC28-M2.1</td>
<td>Bldg 28 Automotive Technology – Mechanical Roof Plan</td>
<td>05/22/18</td>
</tr>
<tr>
<td>CC28-M7.1</td>
<td>Bldg 28 Automotive Technology – Control Diagrams</td>
<td>05/22/18</td>
</tr>
<tr>
<td>CC39-M1.1</td>
<td>Bldg 39 Performing Arts Center – Field Survey Info and Mechanical Schedules</td>
<td>05/22/18</td>
</tr>
<tr>
<td>CC39-M2.1</td>
<td>Bldg 39 Performing Arts Center – Mechanical Plans</td>
<td>05/22/18</td>
</tr>
<tr>
<td>CC39-M7.1</td>
<td>Bldg 39 Performing Arts Center – Control Diagrams</td>
<td>05/22/18</td>
</tr>
<tr>
<td>DV-M0.1</td>
<td>DVC Campus Plan</td>
<td>05/22/18</td>
</tr>
<tr>
<td>DV09-M1.1</td>
<td>Bldg 9 Music – Field Survey Info and Mechanical Schedules</td>
<td>05/22/18</td>
</tr>
<tr>
<td>DV09-M2.1</td>
<td>Bldg 9 Music – Mechanical Plans</td>
<td>05/22/18</td>
</tr>
<tr>
<td>DV09-M7.1</td>
<td>Bldg 9 Music – Control Diagrams</td>
<td>05/22/18</td>
</tr>
<tr>
<td>DV11-M1.1</td>
<td>Bldg 11 Kinesiology – Field Survey Info and Mechanical Schedules</td>
<td>05/22/18</td>
</tr>
<tr>
<td>DV11-M2.1</td>
<td>Bldg 11 Kinesiology – Mechanical Plans</td>
<td>05/22/18</td>
</tr>
<tr>
<td>DV11-M2.2</td>
<td>Bldg 11 Kinesiology – Mechanical Plans</td>
<td>05/22/18</td>
</tr>
<tr>
<td>DV11-M7.1</td>
<td>Bldg 11 Kinesiology – Control Diagrams</td>
<td>05/22/18</td>
</tr>
<tr>
<td>DV12-M1.1</td>
<td>Bldg 12 Life and Health Sciences – Field Survey Info and Mechanical Schedules</td>
<td>05/22/18</td>
</tr>
<tr>
<td>DV12-M2.1</td>
<td>Bldg 12 Life and Health Sciences – Mechanical Plans</td>
<td>05/22/18</td>
</tr>
<tr>
<td>DV12-M7.1</td>
<td>Bldg 12 Life and Health Sciences – Control Diagrams</td>
<td>05/22/18</td>
</tr>
</tbody>
</table>
## Contra Costa Community College District

### Mechanical and Controls Design-Build Project

<table>
<thead>
<tr>
<th>Project Code</th>
<th>Project Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-1129 PAC</td>
<td>Boiler Replacement</td>
</tr>
<tr>
<td>C-1130 PAC</td>
<td>Chiller Replacement</td>
</tr>
<tr>
<td>C-1131 AT</td>
<td>Packaged Unit Replacement</td>
</tr>
<tr>
<td>D-1044</td>
<td>Campus-Wide EMS Upgrades</td>
</tr>
<tr>
<td>D-4017</td>
<td>Mechanical Equipment Retrofit</td>
</tr>
<tr>
<td>P-4022</td>
<td>AHU Replacement</td>
</tr>
</tbody>
</table>

---

### LIST OF DRAWINGS

<table>
<thead>
<tr>
<th>Sheet No.</th>
<th>Drawing Title</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>DV23-M1.1</td>
<td>Bldg 23 Performing Arts Center – Field Survey Info and Mechanical Schedules</td>
<td>05/22/18</td>
</tr>
<tr>
<td>DV23-M2.1</td>
<td>Bldg 23 Performing Arts Center – Mechanical Plans</td>
<td>05/22/18</td>
</tr>
<tr>
<td>DV23-M2.2</td>
<td>Bldg 23 Performing Arts Center – Mechanical Plans</td>
<td>05/22/18</td>
</tr>
<tr>
<td>DV23-M2.3</td>
<td>Bldg 23 Performing Arts Center – Mechanical Plans</td>
<td>05/22/18</td>
</tr>
<tr>
<td>DV23-M7.1</td>
<td>Bldg 23 Performing Arts Center – Control Diagrams</td>
<td>05/22/18</td>
</tr>
<tr>
<td>DV57-M1.1</td>
<td>Bldg 57 Library – Field Survey Info and Mechanical Schedules</td>
<td>05/22/18</td>
</tr>
<tr>
<td>DV57-M2.1</td>
<td>Bldg 57 Library – Mechanical Plans</td>
<td>05/22/18</td>
</tr>
<tr>
<td>DV57-M2.2</td>
<td>Bldg 57 Library – Mechanical Plans</td>
<td>05/22/18</td>
</tr>
<tr>
<td>DV57-M2.3</td>
<td>Bldg 57 Library – Mechanical Plans</td>
<td>05/22/18</td>
</tr>
<tr>
<td>DV57-M2.4</td>
<td>Bldg 57 Library – Mechanical Plans</td>
<td>05/22/18</td>
</tr>
<tr>
<td>DV57-M2.5</td>
<td>Bldg 57 Library – Mechanical Plans</td>
<td>05/22/18</td>
</tr>
<tr>
<td>DV57-M2.6</td>
<td>Bldg 57 Library – Mechanical Plans</td>
<td>05/22/18</td>
</tr>
<tr>
<td>DV57-M7.1</td>
<td>Bldg 57 Library – Control Diagrams</td>
<td>05/22/18</td>
</tr>
<tr>
<td>DV57-M7.2</td>
<td>Bldg 57 Library – Control Diagrams</td>
<td>05/22/18</td>
</tr>
<tr>
<td>DV92-M2.1</td>
<td>Bldg 92 Physical Sciences – Mechanical Plans</td>
<td>05/22/18</td>
</tr>
<tr>
<td>DV92-M7.1</td>
<td>Bldg 92 Physical Sciences – Control Diagrams</td>
<td>05/22/18</td>
</tr>
<tr>
<td>DO-M1.1</td>
<td>District Office – Mechanical Schedule and AHU Detail</td>
<td>05/22/18</td>
</tr>
<tr>
<td>DO-M2.1</td>
<td>District Office – Mechanical Plans</td>
<td>05/22/18</td>
</tr>
<tr>
<td>DO-M7.1</td>
<td>District Office – Control Diagrams</td>
<td>05/22/18</td>
</tr>
</tbody>
</table>

**End of List of Drawings**
PART 1 – GENERAL

1.1 SUMMARY

A. Section includes design and provision of formed steel stud exterior wall framing to resist lateral and uplift loads; accessories such as clips, stiffeners, bridging, bracing and fasteners.

B. Related Sections:
   1. Division 8: Coordination of framing for installation and support of doorway system openings.
   2. Section 09 21 16 - Gypsum Board Assemblies: Gypsum sheathing; non-load bearing interior metal stud framing.
   3. Section 09 24 00 – Cement Plastering: Coordination of framing for installation and support of plaster cladding system.

1.2 REFERENCES

A. American Iron and Steel Institute:
   1. AISI General - Standard for Cold-Formed Steel Framing - General Provisions.
   2. AISI Header - Standard for Cold-Formed Steel Framing - Header Design.
   3. AISI NAS - North American Specification for Design of Cold-Formed Steel Structural Members.

B. ASTM International:
   2. ASTM A1003 - Standard Specification for Steel Sheet, Carbon, Metallic- and Nonmetallic-Coated for Cold-Formed Framing Members.
   3. ASTM C955 - Standard Specification for Load-Bearing (Transverse and Axial) Steel Studs, Runners (Tracks), and Bracing or Bridging for Screw Application of Gypsum Panel Products and Metal Plaster Bases.
   4. ASTM C1007 – Installation of Load Bearing Steel Studs and Related Accessaries.

C. American Welding Society:
   1. AWS D1.1 - Structural Welding Code - Steel.
   2. AWS D1.3 - Structural Welding Code - Sheet Steel.

D. Gypsum Association:

E. SSPC: The Society for Protective Coatings:
   1. SSPC Paint 20 - Zinc-Rich Primers (Type I - Inorganic and Type II - Organic).

F. Steel Stud Manufacturers Association:
   1. SSMA - Product Technical Information.

G. Underwriter’s Laboratories
   1. UL Directory.

1.3 PERFORMANCE REQUIREMENTS

A. System Design: Provide cold-formed metal wall and soffit framing capable of withstand design load within limits and under conditions indicated.
   1. Design Loads: Calculated in accordance with the current version of the California Building Code, with requirements depicted on design-build documents.
   3. Design to AISI NAS, AISC General, and AISC Header.
   4. Design to provide for movement of components without damage, connection failure, sheathing failure, failure of joint seals, undue stress on fasteners and anchors, or other detrimental effects when subject to cyclic day/night temperature range and up to a maximum ambient temperature change of 120 degrees F.
   5. Design system to accommodate:
      a. Construction tolerances, deflection of building structural members, and clearances of intended openings.
      b. Expansion and contraction of members and building movement without damage to connections or members.
      c. Live load deflection of primary building structure, up to 1/2 inch of upward and downward movement.
   6. Seismic Loads: Design and size components to withstand seismic loads and sway displacement as calculated in accordance with current version of the California Building Code. System shall accommodate horizontal deflection without regard for contribution of sheathing materials. Refer to Drawings for designated locations of deflection / slip joints.

1.4 SUBMITTALS

A. Agreement for Mechanical and Control Design-Build Project - Submittal Procedures: Submittal requirements.

B. Product Data: Submit data on standard framing members; describe materials and finish, product criteria, limitations.

C. Shop Drawings:
1. Indicate component details, framed openings, anchorage, welds, type and location of fasteners, and accessories or items required of related Work. Show reinforcing channels, supplemental framing, strapping, bracing, bridging, splices, accessories, and attachment to adjoining work.

2. Indicate stud and soffit joist layout.

3. Describe method for securing studs to tracks and for bolted or welded framing connections.

D. Design Data: Submit design calculations prepared and signed by a California-licensed professional engineer.

E. Mill Certifications: Submit mill certifications for steel delivered to site. Certify steel bare metal thickness in 0.001 inch, yield strength, tensile strength, total elongation in 2 inch or 8 inch gauge length, chemical analysis, and galvanized coating thickness.

F. Welding Certificates: Copies of certificates for welding procedures and personnel.

1.5 QUALITY ASSURANCE

A. Calculate structural properties of framing members in accordance with AISI NAS.

B. Furnish framing materials in accordance with SSMA - Product Technical Information.

C. Perform Work in accordance with the following:
   1. Framing: AISI General and AISI NAS.
   3. Wall Studs: AISI WSD.

1.6 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three years’ experience and a current member of Steel Stud Manufacturers Association.

B. Installer: Company specializing in performing Work of this section similar in material, design, and extent to that indicated for this Project and whose work has resulted in construction with a record of in-service performance.

C. Design structural elements under direct supervision of Professional Engineer experienced in design of this Work and licensed in State of California.

D. Welding: Qualify procedures and personnel according to AWS D1.1 and AWS D1.3.

E. Fire-Test-Response Characteristics: Where metal framing is part of a fire-resistive rated assembly, provide framing identical to that of assemblies tested for fire resistance per ASTM E119 by a testing and inspecting agency acceptable to authorities having jurisdiction.
1. Fire Resistance Ratings: Indicated by GA File Numbers in GA-600, or by design designations from UL Directory, or from the listings of another testing and inspecting agency.

1.7 DELIVERY, STORAGE AND HANDLING

A. Deliver, store and handle products in a manner to prevent damage and deterioration, including rust.

B. Store materials above the ground in a dry area, in manufacturer's original packaging. Keep labels showing product type, name and grade intact.

PART 2 – PRODUCTS

2.1 COLD-FORMED METAL FRAMING

A. Manufacturers: Compliant products of one of the following, or approved equal.

1. California Expanded Metal Products Company / CEMCO.

2. ClarkDietrich Building Systems LLC.

3. SCAFCO Corporation.


B. Cold-Formed Metal Framing: ASTM C955.

2.3 FRAMING COMPONENTS

A. Steel Sheet: ASTM A1003; Structural Grade, Type H, metallic coated.

1. Grade: ST50H for 16-gauge and heavier members.

2. Coating: G60 galvanized.

B. Studs: Steel sheet, formed to C-shape, punched web; thickness (gauge) as determined from Performance Requirements, 1.625 inch minimum face (flange) and 6 inch minimum depth unless indicated otherwise on Drawings.

C. Joists: Steel sheet, formed to C-shape, solid web; thickness (gauge) and depth as determined from Performance Requirements, 1.625 inch minimum face (flange).

D. Track: Steel sheet, formed to channel shape; same width and thickness (gauge) as studs, tight fit; solid web.

E. Slotted Track: Steel sheet, formed to channel shape; same width and thickness (gauge) as studs, tight fit; solid web. Slotted track shall have 2-1/2 inch minimum face (flange) with slotted holes to accommodate a total vertical movement of 1-1/2 inch minimum. Slotted track shall have minimum 1-1/2 inch long slotted holes in web to accommodate horizontal drift.

2.4 ACCESSORIES
A. Bracing, Furring, Bridging: Formed sheet steel, thickness determined by performance requirements specified.

B. Plates, Gussets, Clips: Formed sheet steel, thickness determined by performance requirements specified.

C. Backing Plates: Formed steel sheet or c-shapes if indicated, 16 gauge or thickness as indicated.

D. Touch-Up Primer for Galvanized Surfaces: ASTM A780 or SSPC Paint 20.

2.5 FASTENERS

A. Self-drilling, Self-tapping Screws, Bolts, Nuts, and Washers: Steel, hot dip galvanized unless otherwise indicated on Drawings.

B. Anchorage Devices: Power actuated, drilled expansion bolts: Steel, hot dip galvanized unless otherwise indicated on Drawings.

C. Welding: In conformance with AWS D1.1 and AWS D1.3.

2.6 FABRICATION

A. Shop fabrication, where applies:
   1. Fabricate assemblies of formed sections of sizes and profiles required.
   2. Fit, reinforce, and brace framing members to suit design requirements.
   3. Fit and assemble in largest practical sections for delivery to site, ready for installation.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Agreement for Mechanical and Control Design-Build Project - Administrative Requirements: Coordination and project conditions.

B. Verify substrate surfaces and building framing components are ready to receive Work. Verify that inserts, clips, and similar attachment devices installed as work of other sections are located and installed properly.

C. Verify rough-in utilities are in proper location.

3.2 ERECTION OF STUDS

A. Comply with requirements of ASTM C1007 except where exceeded by other requirements.

B. Align floor and ceiling tracks; locate to wall layout. Secure in place with fasteners or by welding as shown on Drawings, at maximum 24 inches oc, and in accordance with approved shop drawings. Coordinate installation of sealant with floor and ceiling tracks where indicated.
COLD-FORMED METAL FRAMING
Mechanical and Controls Design-Build Project

C-1129 PAC Boiler Replacement D-1044 Campus-Wide EMS Upgrades
C-1130 PAC Chiller Replacement D-4017 Mechanical Equipment Retrofit
C-1131 AT Packaged Unit Replacement P-4022 AHU Replacement

1. Provide slotted track at stud heads to provide for vertical movement and drift of adjoining structure without loading of the metal framing.

C. Place studs at not more than 16 inches oc; not more than 2 inches from abutting walls and at each side of openings. Connect studs to tracks using fasteners, or welding method where indicated.

D. Construct corners using minimum three studs. Double stud wall openings, door jambs, and window jambs.

E. Erect load bearing studs one piece full length. Splicing of studs is not permitted.

F. Erect load bearing studs, brace, and reinforce to develop full strength, to achieve design requirements.

G. Fully seat axial loaded studs in receiving tracks maximum 1/16 inch gap between stud and track web.

H. Coordinate placement of insulation in multiple stud spaces after erection.

I. Install intermediate studs above and below openings to align with wall stud spacing.

J. Install studs with deflection allowance in stud track, directly below horizontal building framing at non-load bearing framing.

K. Attach cross studs or furring channels to studs for attachment of fixtures anchored to walls.

L. Install framing between studs for attachment of mechanical and electrical items, and to prevent stud rotation.

M. Install backing plates as required for roofing system and flashing securement.

N. Touch-up field welds and damaged metallic coatings with primer to match shop coating.

O. Complete framing ready to receive gypsum board and sheathing panels, cladding and roofing systems.

3.3 ERECTION TOLERANCES

A. Install cold-formed metal framing level, plumb and true to line to a maximum allowable tolerance variation of 1/8 inch in 10 feet.

END OF SECTION
PART 1 - GENERAL

1.1 SUMMARY

A. Section includes design, provision, and installation of shop fabricated metal items and related accessories and fasteners as indicated in Drawings, including but not necessarily limited to the following:

1. Standard steel pipe railings at DVC Theater Roof
2. Standard steel catwalk and railings at DVC Library Plenum
3. Fasteners and anchors for framing and miscellaneous anchorages.
4. Structural supports for miscellaneous anchorages.

B. Related Sections:

1. Section 05 40 00 – Cold Formed Metal Framing.
2. Section 09 21 16 – Gypsum Board Assemblies.
3. Section 09 90 00 – Painting and Coatings: Field applied paint finish.

1.2 REFERENCES

A. Aluminum Association (AA)
1. AA DAF-45 – Designation System for Aluminum Finishes

B. American Architectural Manufacturers Association (AAMA)

C. American National Standards Institute
1. ANSI A14.3 – Ladders – Fixed – Safety Requirements
D. ASTM International
   5. ASTM A307 - Standard Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength.
   8. ASTM A500 - Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.

E. American Welding Society (AWS)
   1. AWS A2.4 - Standard Symbols for Welding, Brazing, and Nondestructive Examination.
   2. AWS D1.1 – Structural Welding Code – Steel
   3. AWS D1.6 – Structural Welding Code – Stainless Steel

F. California Code of Regulations, Title 8, Agreement for Mechanical and Control Design-Build Project, Chapter 4, Subchapter 7 (CCR):
   1. GISO – General Industry Safety Orders: Group 1 General Physical Conditions and Structures Orders.

G. California Code of Regulations, Title 24, Part 2 (CCR):
   1. CBC – California Building Code: Design of architectural components.

H. National Association of Architectural Metal Manufacturers (NAAMM)

I. National Ornamental & Miscellaneous Metals Association (NOMMA)
   1. NOMMA Guideline 1 – Joint Finishes.

J. The Society for Protective Coatings (SSPC)
   1. SSPC - Steel Structures Painting Manual.
   2. SSPC SP 1 – Solvent Cleaning.
   3. SSPC SP 10 – Near-White Blast Cleaning.
   4. SSPC Paint 20 – Zinc Rich Primers (Type I – Inorganic and Type II – Organic).

1.3 QUALITY ASSURANCE

A. Welding Qualifications: Welders shall be qualified in accordance with AWS D1.1.

B. Design Criteria:
   1. Finish joints in accordance with NOMMA Guideline 1.
   2. Built-up parts shall not exhibit warp.

1.4 SUBMITTALS

A. Shop Drawings:
   1. Show large scale construction of various parts, methods of joining, thickness of metals, profiles of surfaces, reinforcing, anchorage, and structural supports. Include information regarding concealed and exposed joints, welds, and fastenings.
   2. Where welded connectors and concrete inserts are required to receive work, show size and locations required.

B. Welders Certificates: Certify welders employed on the Work, verifying AWS qualification within previous 12 months.

1.5 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Deliver, store, and handle packaged materials in original containers with seals unbroken and labels intact until time of use.

B. Discharge materials carefully and store on clean concrete surface or raised platform in safe, dry area.

1.6 JOB CONDITIONS

A. Scheduling, Sequencing:
   1. Ensure timely fabrication of items to be embedded or enclosed by other work.
2. Furnish information and assistance required for locating embedded items and be responsible for proper locations.

PART 2 - PRODUCTS

2.1 COMPONENTS - STEEL

A. Steel Plates, Channels, Angles, and Tees: ASTM A36.
B. Steel Plate: ASTM A572, Grade 50.
C. Steel Tubes: ASTM A500, Grade B.
D. Steel Pipe: ASTM A53, Grade B, Schedule 40.
E. Steel Sheet: ASTM A653, Grade 33 Structural Quality, Galvanized.
F. Bolts: ASTM A307 Grade A or ASTM A325, Type 1.
G. Nuts: ASTM A563 heavy hex type.
H. Washers: ASTM F436, Type 1.
I. Welding Materials: AWS D1.1; type required for materials being welded.
J. Shop Primer: SSPC Paint 15, Type 1, red oxide.
K. Touch Up Primer: Match shop prime, or SSPC Paint 20 for Galvanized surfaces

2.2 COMPONENTS – STAINLESS STEEL

A. Bars and Shapes: ASTM A276, Type 304 unless shown otherwise.
B. Tubing: ASTM A269, Type 304 unless shown otherwise.
C. Pipe: ASTM A312, Type 304 unless shown otherwise.
D. Plate, Sheet and Strip: ASTM A240, Type 304 unless shown otherwise.
F. Welding Materials: AWS D1.6; type required for materials being welded.

2.3 COMPONENTS – ALUMINUM

A. Extruded Aluminum: ASTM B221, Alloy 6063, Temper T5.
B. Sheet Aluminum: ASTM B209.
C. Bolts, Nuts and Washers: Stainless Steel.
D. Welding Materials: AWS D1.1, type required for materials being welded.

2.4 COMPONENTS - ANCHORS

A. Anchor Rods: ASTM A307, Grade A or ASTM F1554, Grade 55, weldable. Furnish with nut and washer, unfinished.

   1. Patching Mortar: BASF’s “EMACO S66 CI”, Sika Corporation’s “SikaRepair 223” or equal.

2.5 FABRICATION

A. Preparation:
   1. Coordinate with other work supporting or adjoining miscellaneous metal and verify requirements of cutting out, fitting, and attaching.
   2. Verify sizes, designs, and locations of items; do so at site whenever construction progress permits.

B. General Requirements
   1. Fabricate items from materials noted and make true to profiles shown. Obtain Architect’s approval of proposed variations.
   2. Miter corners and angles of frames and moldings unless otherwise noted.
   3. Perform cutting, shearing, drilling, punching, threading, tapping as required for items or their adjacent work.
   4. Drill or punch holes; do not use cutting torch.
   5. Ensure shearing and punching leaves true lines and surfaces.
   6. Items to be Galvanized: Fabricate in accordance with recommended practices of ASTM A385 and A386 unless specifically noted otherwise.
   7. Fabricate exterior items for assembly and installation on site without field-welding of joint.
   8. Ensure metal thickness and assembly details provide ample strength and stiffness.
   9. Size sleeves for approximately 1/4-inch clearance all around.

C. Fastening:
   1. Provide fasteners and anchor assemblies required for complete fabrication, field assembly, and erection.
   2. Conceal fastenings wherever practicable.
   3. Size internally threaded diameters to accommodate galvanized threaded bolts where galvanizing is required.
4. Permanent connections in Ferrous Metal Items: Employ welding wherever practicable; avoid bolts and screws.

D. Welding:
   1. Use electric shielded-arc process according to AWS D1.1 and AWS D1.3.
   2. Maintain shape and profile of item welded.
   3. Prevent heat blisters, run-throughs, and surface distortions.
   5. Exposed Welds: Remove burrs, flux, welding oxide, air spots and discoloration; grind smooth, polish, or otherwise finish to match material welded.

2.6 FINISHES

A. Preparations of Surfaces:
   1. Thoroughly clean mill scale, rust, dirt, grease, and other foreign matter from ferrous metal prior to galvanizing, hot phosphate treatment or painting.
   2. Where hand cleaning methods are not adequate, clean in accordance with SSPC-SP 1, SSPC-SP 2, or SSPC-SP 7 as required.
   3. Completely eliminate burrs, rough spots and pitting from normally exposed ferrous metal items.

B. Galvanizing:
   1. Galvanize items after fabrication in largest sections practicable unless otherwise permitted or recommended by ASTM A384 and A385.
   2. Where galvanizing is removed by welding or other assembly procedures, touch up abraded areas with molten zinc or zinc-rich paint.
   3. Where ferrous metal item is noted to be galvanized, perform galvanizing in accordance with following standards as applicable to item:
      b. Other Fabricated items: ASTM A123.

C. Finish Schedule: Unless noted otherwise in Materials or Standard Catalog Products Articles.
   1. Ferrous Metal, Interior Items:
      a. Concealed: Clean, chemically etch, and shop-apply one prime-coat.
      b. Exposed: Clean, treat with hot phosphate, chemically etch, and shop-apply one prime-coat.
   2. Ferrous metal, Exterior Items:
      a. Concealed: Clean and hot-dip galvanize in accordance with galvanizing standards.
2.7 METAL FABRICATION ITEMS

A. Miscellaneous: Provide miscellaneous metal fabricated angles, channels, plates and shapes, threaded rods, pipe, bolts, nuts, washers, spacers, and fastenings shown or otherwise required to complete Work.

B. Standard Steel Pipe Railings at DVC Theater Roof:


   a. OSHA 1910.29 Compliance:

      i. 1910.29(b)(1): The top edge height of top rails, or equivalent guardrail system members, are 42 inches (107 cm), plus or minus 3 inches (8 cm), above the walking-working surface. The top edge height may exceed 45 inches (114 cm), provided the guardrail system meets all other criteria of paragraph (b) of this section (see Figure D-11 of this section).

      ii. 1910.29(b)(2): Midrails, screens, mesh, intermediate vertical members, solid panels, or equivalent intermediate members are installed between the walking-working surface and the top edge of the guardrail system as follows when there is not a wall or parapet that is at least 21 inches (53 cm) high:

         a. 1910.29(b)(2)(i): Midrails are installed at a height midway between the top edge of the guardrail system and the walking-working surface.

         b. 1910.29(b)(2)(ii): Screens and mesh extend from the walking-working surface to the top rail and along the entire opening between top rail supports.

         c. 1910.29(b)(2)(iii): Intermediate vertical members (such as balusters) are installed no more than 19 inches (48 cm) apart; and

         d. 1910.29(b)(2)(iv): Other equivalent intermediate members (such as additional midrails and architectural panels) are installed so that the openings are not more than 19 inches (48 cm) wide.

b. Exposed: Clean, then hot-dip galvanize in accordance with galvanizing standards, chemically etch, and shop-apply one prime-coat.

3. Special Ferrous Metal Items as Noted Below: Clean and hot-dip galvanize in accordance with galvanizing standards. Do not prime coat.

   a. Standard steel catwalk and railings at DVC Library Plenum.

4. Items Noted as Chrome-Plated: Same as US26D finish.

5. Hardware Including Fasteners (Bolts, Nuts, Washers, Etc.) and Anchors:

   a. Finish to match items fastened or as shown. Furnish stainless steel expansion anchors at exterior locations and where indicated on Drawings.

   b. Where galvanizing is required, hot-dip galvanize according to ASTM A153.
vii. 1910.29(b)(3): Guardrail systems are capable of withstanding, without failure, a force of at least 300 pounds (890 N) applied in a downward or outward direction within 2 inches (5 cm) of the top edge, at any point along the top rail. (Note that force requirement for this project is greater than the minimum specified in OSHA)

viii. 1910.29(b)(4): When the 300-pound (890-N) test load is applied in a downward direction, the top rail of the guardrail system must not deflect to a height of less than 39 inches (99 cm) above the walking-working surface. (Note that force requirement for this project is greater than the minimum specified in OSHA)

ix. 1910.29(b)(5): Midrails, screens, mesh, intermediate vertical members, solid panels, and other equivalent intermediate members are capable of withstanding, without failure, a force of at least 200 pounds (667 N) applied in any downward or outward direction at any point along the intermediate member. (Note that force requirement for this project is greater than the minimum specified in OSHA)

x. 1910.29(b)(6): Guardrail systems are smooth-surfaced to protect employees from injury, such as punctures or lacerations, and to prevent catching or snagging of clothing.

xi. 1910.29(b)(7): The ends of top rails and midrails do not overhang the terminal posts, except where the overhang does not pose a projection hazard for employees.

xii. 1910.29(b)(8): Steel banding and plastic banding are not used for top rails or midrails.

xiii. 1910.29(b)(9): Top rails and midrails are at least 0.25-inches (0.6 cm) in diameter or in thickness.

2. Anchorage to existing structure: Design and install railing post anchorage to primary building structure or exterior structural framing in a manner that maintains weather tight envelope using flashing and sealant as required

3. Exposed Fasteners: Flush countersunk screws or bolts; consistent with design of railing.

B. Standard steel catwalk and railings at DVC Library plenum:

1. General: Design and fabricate catwalk beams, guardrails, and walking surface to replace existing wood platform at locations indicated on Drawings, in compliance with applicable provisions of NAAMM Pipe Railing Manual, OSHA, and California Building Code.

2. Structural Requirements: Platform shall be designed in accordance with CBC Chapter 16 structural requirements, including a minimum uniform live load of 40 psf, and a concentrated load of 300 pounds.

3. Beams: Catwalk beams shall consist of structural wide flange beams and/or C-channels as required to span between existing structural wide-flange beams and meet design load requirements. Catwalk beams shall be welded, bolted, or clamped to existing beams.

4. Guardrails: As specified in Section 2.7_B above, bolted or welded to catwalk beams.

5. Walking surface: Comprised of galvanized steel welded bar-grating or plank-grating set across and anchored to top of catwalk beams along entire length of catwalk. Grating size to be designed to meet structural criteria as indicated.

6. Finish: Galvanized in compliance with Finishes article.

PART 3 - EXECUTION

3.1 INSPECTION

A. Examine areas to receive work and verify that: Setting conditions and dimensions are correct to receive items.

B. Do not start installation until unsatisfactory conditions have been corrected.

3.2 INSTALLATION
A. Install work plumb, true, rigid, and neatly trimmed out.

B. Do not tighten fastener through finish alone without spacer washers.

C. Provide concrete inserts or predrilled expansion bolts in fastening items into concrete. Install and tighten expansion anchors in accordance with manufacturer's recommendations and referenced Reports. Coordinate for inspection and testing as required. Clean and repair surfaces damaged by drilling or installation and fill abandoned holes with patching mortar in accordance with the manufacturer's instructions. Correction of defective work shall be the responsibility of the Design Builder.

D. Protect dissimilar metals from contact with each other or with other materials causing corrosion.

E. Fasten work tightly to prevent rattle or vibration except where expansion-contraction tolerances are required.

F. Use non-shrink grout mixed in accordance with manufacturer's direction for setting frames, plates, sills, bolts and similar items.

G. Set items shown or required to be installed in sleeves with quick-setting anchor cement unless otherwise noted.

H. Protect metal from damage to surface, profile and shape.

3.3 CLEANING

A. Remove protective devices only when items will safe from other construction operations or removal is required to permit related work.

B. Touch up and clean prime-coated items as required for finish painting per Section 09 90 00.

END OF SECTION
PART 1 – GENERAL

1.1 SUMMARY

A. Section includes:
   1. Patching and repair of existing Built-up asphalt roofing at installation of DVC Theater guard rails, and new doors to DVC Library plenum.

B. Related Sections:
   1. Section 07 62 00 - Sheet Metal Flashing and Trim

1.2 REFERENCES

A. American Society for Testing and Materials (ASTM):
   5. ASTM D312 - Standard Specification for Asphalt used in Roofing.
B. FM Global:
   1. FM DS 1-28 - Wind Loads to Roof Systems and Roof Deck Securement.
   2. FM - Approval Guide.

C. Intertek Testing Services (Warnock Hersey Listed):
   1. WH - Certification Listings.

D. National Roofing Contractors Association:
   1. NRCA - The NRCA Roofing and Waterproofing Manual.

E. Underwriters Laboratories Inc.:
   1. UL - Fire Resistance Directory.
   3. UL 1256 - Fire Test of Roof Deck Construction.
   4. UL 1897 - Uplift Tests for Roof Covering Systems.

F. U.S. Environmental Protection Agency:
   1. ENERGY STAR - ENERGY STAR Voluntary Labeling Program.

1.3 PERFORMANCE REQUIREMENTS

A. General: Installed roofing membrane system shall remain watertight and resist specified wind uplift pressures, thermally induced movement, and exposure to weather without failure.

B. Material Compatibility: Roofing materials shall be compatible, of single manufacturer or recommended accessories by roofing manufacturer based on testing and field experience.

C. Uplift Resistance: UL 1897; 90 psf uplift pressure resistance; Factory Mutual I-90.

1.4 SUBMITTALS

A. Agreement for Mechanical and Control Design-Build Project - Submittal Procedures: Submittal procedures.

B. Product Data: Submit data indicating system and proposed components.
   1. Roofing manufacturer’s mechanical fastener pattern providing specified uplift resistance. Include increased fastening for corner and perimeter areas.

C. Warranty.

1.5 QUALITY ASSURANCE

A. Perform Work in accordance with manufacturer’s specifications and NRCA Roofing and Waterproofing Manual.
B. Roof Assembly Fire Classification: Minimum Class A when tested in accordance with ASTM E108 or UL 790.
   1. Roof Assembly with Foam Insulation: Passes FM 4450 or UL 1256.

C. Surface Burning Characteristics:
   1. Foam Insulation: Maximum 75/450 flame spread/smoke developed index when tested in accordance with ASTM E84.

D. Apply label from agency approved by authority having jurisdiction to identify each roof assembly component.

E. Re-Roofing Hazardous Materials: Design Builder shall perform sufficient inspections and tests to confirm Owner’s asbestos test results, if performed, or to provide initial determination of presence of any asbestos-containing existing roofing materials to be disturbed or removed in the accomplishment of the re-roofing job. “Asbestos containing materials” contain an amount greater than 0.10% by weight of asbestos fiber measured by standard laboratory procedures such as EPA-600/M4-82-020 polarized light microscopy (PLM). “Disturbed or removed” includes any activity that might release fibers into the air. Asbestos containing materials known to exist or found in the Design Builder’s work areas at any time during the course of re-roofing work will be dealt with as required by law and these specifications at no additional cost to the Owner.

1.6 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three years’ experience.

B. Installer: California licensed Design Builder specializing in performing Work of this section with minimum three years documented experience, approved by manufacturer.

1.7 PRE-INSTALLATION MEETINGS

A. Agreement for Mechanical and Control Design-Build Project - Administrative Requirements: Pre-installation meetings.

B. Before the start of Work, meet at the Project site to review methods and sequence of installation, special details and conditions, quality standards, testing and quality control requirements, job organization and other pertinent topics related to the Work. The meeting shall include the Owner, Architect, Design Builder, and subcontractors whose work is relevant to this Specification Section. Include job walk with all attendees. Provide at least one week advance notice to participants prior to convening pre-installation meeting.
   1. Manufacturer’s Representative: Present as required for compliance with manufacturer’s warranty requirements during installation and shall review and approve completion of roof installation

C. Review preparation and installation procedures and coordinating and scheduling required with related Work.

1.8 DELIVERY, STORAGE, AND HANDLING
A. Agreement for Mechanical and Control Design-Build Project - Product Requirements: Product storage and handling requirements.

B. Deliver products in manufacturer’s original containers, dry, undamaged, with seals and labels intact.

C. Store products in weather protected environment, clear of ground and moisture.

D. Store rolled goods on end with weatherproof covering.

1.9 ENVIRONMENTAL REQUIREMENTS

A. Agreement for Mechanical and Control Design-Build Project - Product Requirements.

B. Weather Limitations: Proceed with installation only when current and forecasted weather conditions permit roofing system to be installed in accordance with manufacturer's written instructions and warranty requirements.

C. Apply only dry materials. Do not leave materials open or uncovered on roof overnight. Remove wet material from jobsite.

1.10 COORDINATION

A. Agreement for Mechanical and Control Design-Build Project - Administrative Requirements: Coordination and project conditions.

B. Coordinate Work with installation of associated roof penetrations and counterflashings installed by other sections as Work of this section proceeds.

1.11 WARRANTY

A. Agreement for Mechanical and Control Design-Build Project - Execution and Closeout Requirements: Product warranties and product bonds.

B. Furnish manufacturer’s No Dollar Limit labor and materials system warranty.

1. Single-Source special warranty includes roofing plies, base flashings, liquid applied flashing, roofing membrane accessories, granule surfaced roofing membrane, roof insulation, fasteners, cover board, walkway products, and other single-source components of roofing system marketed by the manufacturer.

2. Warranty Period: 20 years from date of Substantial Completion.

3. Riders: Warranty shall not exclude coverage for wind events up to 80 miles per hour or for hail events up to 1 inch.

PART 2 – PRODUCTS

2.1 BUILT-UP ASPHALT ROOFING

A. Manufacturers: Provide compliant products of one of the following or approved equal:
3. CertainTeed Corporation / Saint-Gobain.

B. System Description: NRCA Assembly: BU-4-I-A-M; mechanically attached insulation installed over nailable wood deck with adhered cover board, four-ply asphalt membrane system and California Title-24-compliant fiberglass cap sheet finish. Basis of Specification: Johns Manville Corporation's "4GIC-CR". Components listed below are products of Johns Manville except where noted otherwise.

2.2 COMPONENTS

A. Asphalt Bitumen: ASTM D312 Type recommended by manufacturer for roofing material, slope and location. Flash point shall exceed 520 degrees F, bulk asphalt heated in tankers not permitted.

B. Base Sheet: ASTM D4601, Type II; SBS rubber modified, asphaltic fiberglass mat capable of being mechanically fastened or mopped in hot asphalt.

C. Glass Fiber Felts (Stripping Plies): ASTM D2178, Type VI, asphalt saturated. "GlasPly Premier".

D. Fiberglass Cap Sheet: ASTM D3909; white mineral-surfaced, white acrylic-coated with minimum aged E. Solar Reflectance of 0.55 and minimum Thermal Emittance of 0.75, or a minimum SRI of 64. "GlasKap CR".

E. Base Flashing: ASTM D6164, Type I, Grade S polyester reinforced, smooth surfaced, SBS modified bitumen cap sheet. "Dynalastic 180 S".

   1. Base Flashing assemblies include specified Fiberglass Cap Sheet when specified in Part 3 – Execution.

F. Rigid Insulation: ASTM C1289, Type-II, Class 1, faced rigid cellular polyisocyanurate roof insulation, CBC-compliant for foam plastic insulation. Straight and tapered versions required to achieve thickness and slopes shown on Drawings. "ENERGY 3 25 PSI", Firestone Corporation's "ISO 95+ GL" or approved equal.

   1. Compressive Strength: 20 psi minimum.
   2. Long Term Thermal Resistance (LTTR) Value: 6.0 per inch thickness minimum.

G. Cover Board: 1/2 inch thick, ASTM C728, Type 2, expanded perlite mineral aggregate board; with asphaltic top coating and minimum R-Value of 1.0. "1/2" Retro-Fit Board”.

H. Cant Strips: ASTM C728, laminated expanded perlite, 4 inches installed height. "FesCant Plus Cant Strip”. Pre-formed to 45 degree angle or configuration as detailed.

I. Tapered Edge Strips: ASTM C728, laminated expanded perlite, 18 inch length or as shown. "Tapered Fesco Edge Strip”.

2.3 ACCESSORIES

A. Strip Reglet Devices: Galvanized steel, maximum possible lengths per location, with attachment flanges.

B. Insulation Fasteners: Appropriate for purpose intended and approved by Factory Mutual and system manufacturer; length required for thickness of insulation material and penetration of deck substrate, with square metal washers.

C. Roofing Nails: Galvanized, hot dipped or non-ferrous type with integral tincaps where required. Size and configuration as recommended by manufacturer and as required to suit application.

D. Metal Backing: Furnished under Section 05 40 00.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Agreement for Mechanical and Control Design-Build Project - Administrative Requirements: Coordination and project conditions.

B. Verify surfaces and site conditions are ready to receive work, including new deck materials installed under another Section.

C. Verify deck is supported and secure.

D. Verify deck is clean and smooth, flat, free of depressions, waves, or projections, properly sloped to drains, valleys, or eaves, and suitable for installation of roof system. Verify adjacent plywood sheets do not vary more than 1/4 inch in height.

E. Verify deck surfaces are dry. Confirm dry deck by moisture meter with moisture content acceptable to roofing manufacturer.

F. Verify roof openings, curbs, wood cant strips, wood nailing strips and penetrations through roof are solidly set, and drains are securely clamped in place.

G. Verify metal backing is properly located as required for securement of roofing and flashings to framed vertical surfaces of walls and parapets.

G. Proceed with installation only after unsatisfactory conditions have been corrected.
3.2 PREPARATION

A. Sweep deck. Remove all old roofing fasteners, sharp projections, and remaining materials harmful to new roofing application.

B. Prevent materials from entering drains or conductors or from spilling onto adjacent surfaces. Remove drain plugs when no work is taking place or when rain is forecast.

C. Prime concrete or masonry surfaces with specified primer per manufacturer’s directions. Allow primer to dry.

3.3 APPLICATION

A. Nailer Application:
   1. General: Provide Membrane nailers at roof slopes exceeding 1 inch in 12 feet (1:12).
   2. Install nailing strips the same thickness of the insulation and 3-1/2 inches minimum width at right angles to the roof slope. Locate and secure nailers to deck per manufacturer’s recommendations.

B. Asphalt Control:
   1. Heat asphalt to within 25 degrees plus or minus of equiviscuous temperature (EVT) published by the asphalt manufacturer. Do not exceed the flash point (FP) or hold above finished blowing temperature for four hours.
   2. Prevent asphalt from penetrating substrate joints, entering building or damaging roofing system components or adjacent building construction.

C. Insulation Application:
   1. Comply with membrane system manufacturer’s written instructions for installation of roof insulation.
   2. Install insulation with long joints in a continuous straight line with end joints staggered between rows, abutting edges and ends between boards and nailers. Fill gaps exceeding 1/4 inch with insulation material.
   3. Mechanically fasten first layer of insulation to wood deck to resist specified uplift per roofing manufacturer’s recommendations.
   4. Build up crickets using additional layers of flat and tapered insulation. Adhere to first layer of insulation with solid mopings of hot roofing asphalt according to roofing system manufacturer’s instructions.

D. Cover Board Installation:
   1. Comply with membrane system manufacturer’s written instructions for installation of roof cover board.
   2. Install cover board with long joints of cover board in a continuous straight line with end joints staggered between rows, abutting edges and ends between boards. Stagger cover board joints 6 inches minimum from insulation joints. Fill gaps exceeding 1/4 inch with
cover board. Cut and fill cover board within 1/4 inch of nailers, projections, and penetrations.

3. Trim surface of cover board where necessary at roof drains so completed surface is flush and does not restrict flow of water.

4. Adhere cover board to insulation with solid mopping of hot roofing asphalt according to roofing system manufacturer’s instructions.

5. Do not leave cover board exposed at the end of the work day.

E. Edge Strip Installation:

1. Install cant strips in hot asphalt at transitions to vertical surfaces per roofing system manufacturer’s instructions.

2. Install edge strips at open perimeters without drains, cricket toes, and other locations to provide smooth surfaces as shown and per roofing system manufacturer’s instructions.

F. Membrane Application:

1. Apply roof felt plies and cap sheet over cover board in accordance with manufacturer’s instructions and NRCA recommendations for roof type and slope. Weather lap edges and ends, mopped with bitumen between each ply.
   a. Prior to applying field plies apply an extra felt in hot asphalt to valleys and crickets.
   b. Begin layup with cut starter sheets. Roll plies in and back broom all plies, including Cap Sheet.
   c. Install felts with long dimension parallel with roof slope where it exceeds 1 inch in 12 feet (1:12). Locate and secure to nailers per manufacturer’s recommendations; nail leading edge of each ply 3/4 inch back on nailer.
   d. Install 18 foot lengths of cap sheet parallel to plies. Nail the upslope edge 3/4 inch back from the leading edge and at approximately 8 inches on center. Set in mopping of hot asphalt. Provide 6 inch end laps, staggered 3 feet minimum between courses. Seed cap sheet asphalt flow-out with matching white granules.

2. Apply plies smooth, free from prominent lap joints, air pockets, wrinkles, fish-mouths, or tears.

3. Extend roof felts and cap sheet to top of cant strips and under gravel stops; secure to nailing strips.

4. Install two plies membrane and bitumen glaze coat for cut-off at end of day’s operation. Glaze felts exposed at end of working day. Remove cut-off before resuming roofing.

5. Cut out defects like fishmouths, skips, buckles or tears. Apply one extra ply in hot asphalt extending 6 inches beyond each defect all around.

6. Mop and seal two additional stripping plies of felt and top layer of base flashing around roof penetration. Cover with cap sheet surfacing where shown on roof plans.

7. Install traffic pads by setting in hot asphalt per roofing system manufacturer’s recommendations. Set pieces 3 inches apart.
Wall, Curb and Base Flashing Installation:

1. Install bituminous flashings wherever built-up roofing abuts steep sloped and vertical surfaces. Installation shall comply with one of the following Johns Manville standard specifications:
   b. Sheathed substrates 24 inches or higher: CR-3 (WH).
   c. Concrete or masonry substrates less than 24 inches high: CR-6 (TL).
   d. Concrete or masonry substrates 24 inches or higher: CR-6 (TH).

2. Use moppings of hot asphalt to adhere plies.

3. Nail the first ply on wooden substrates with tincap nails at 4 inches on center on laps and at 9 inches on center, each way, between laps. Set into hot asphalt only the portion of the first ply covering the cant strip and extending out onto the roof surface.

4. Limit flashing piece length to 8 feet maximum. Do not blanket flashing plies; set each separately with staggered water shedding laps.

5. Wrap flashing corners according to good roofing practice. Seal cap sheet corners with a troweling of flashing cement.

6. Nail through the top edge of the completed flashing with tincap nails at 6 inches on center. For high flashings, top nail both the lower and upper pieces. Seal uppermost top edge with a troweling of flashing cement covering the nail heads.

Metal Flashings and Scupper Liner Installation:

1. Provide wood nailers equal in thickness to the insulation stack around items to be flashed to roofing with steel flashings. Lead flashings do not require nailers.

2. Inspect flashings. All seams should be soldered water tight for steel, burned closed for lead.

3. Prime top and bottom surfaces of flashing flanges. Allow primer to dry.

4. Set flanges on top of the third roofing ply in a full 1/8 inch thick bed of flashing cement.

5. Nail steel flashing flanges through mastic into the underlying wood nailers or surrounding concrete or masonry wall at 4 inches on center, staggered all around. Lead flashings require no nails.

6. Cover flanges with two stripping plies, each in a full mop of hot asphalt. Extend bottom ply 4 inches beyond flange edge all around. Extend top ply 6 inches beyond flange all around.

7. Cover with cap sheet set in hot asphalt.

Edgings Installation: Refer also to Section 07 62 00 – Sheet Metal Flashing and Trim.

1. Install sheet metal edgings with expansion provisions and set on top of the third roofing ply in full 1/8 inch thick bed of flashing cement.
2. Cover metal edging with two stripping plies, each set in hot asphalt. Extend first ply 4 inches and the second ply 6 inches inboard of the edging.

3. Finish with cap sheet set in hot asphalt.

J. Auxiliary Material Installation:

1. Traffic Pads and Pieces:
   a. Set whole pads on cap sheet at ladder mount / dismount points and around mechanical equipment, where shown on roof plan, and at other locations indicated. Back mop and embed whole pieces in hot asphalt. Mastic setting is not permitted.
   b. Set small pad pieces on cap sheet beneath wooden supports to electrical, gas, and condensate lines crossing roof. Embed small pad pieces in flashing cement.

2. Self-Adhering Flashing (SAF):
   a. Underlay parapet caps with SAF with 2-1/2 inch sidelaps and 5 inch end laps extending minimum 4 inches down each vertical face and as shown.
   b. Seal underlay laps with a troweling of manufacturer’s mastic.

3.5 FIELD QUALITY CONTROL

A. Agreement for Mechanical and Control Design-Build Project - Quality Requirements: Field inspection.

B. Require site attendance of roofing material manufacturer’s representative twice during installation of the Work.

C. Test drains for free flow.

3.6 CLEANING

A. Agreement for Mechanical and Control Design-Build Project - Execution and Closeout Requirements: Final cleaning.

B. Remove bituminous markings from finished surfaces.

C. In areas where finished surfaces are soiled by bitumen or other source of soiling caused by Work of this section, consult manufacturer of surfaces for cleaning advice and conform to their instructions.

D. Repair or replace defaced or disfigured finishes caused by Work of this section.

3.7 PROTECTION OF INSTALLED CONSTRUCTION

A. Agreement for Mechanical and Control Design-Build Project - Execution and Closeout Requirements: Protecting installed construction.

B. Where traffic must continue over finished roof membrane, protect surfaces.
C-1129 PAC Boiler Replacement
C-1130 PAC Chiller Replacement
C-1131 AT Packaged Unit Replacement

D-1044 Campus-Wide EMS Upgrades
D-4017 Mechanical Equipment Retrofit
P-4022 AHU Replacement

END OF SECTION
SECTION 07 62 00

SHEET METAL FLASHING AND TRIM

PART 1 – GENERAL

1.1 SUMMARY

A. Section includes flashings, counterflashings, copings and other fabricated sheet metal items.

B. Related Sections:
   1. Section 07 51 13 - Built-Up Asphalt Roofing
   2. Section 08 12 14 - Standard Steel Frames.
   3. Section 09 24 00 - Cement Plastering.
   4. Section 09 90 00 - Painting and Coating: Field painting.
   4. Divisions 23 and 26: Roof curbs for equipment.

1.2 REFERENCES

A. American Architectural Manufacturers Association:
   1. AAMA 611 - Voluntary Specification for Anodized Architectural Aluminum.

B. ASTM International:
   3. ASTM A653 - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.


C. Copper Development Association Inc.:
   1. CDA - Copper in Architecture - Handbook.

D. Federal Specification Unit:
   1. FS TT-C-494 - Coating Compound, Bituminous, Solvent Type, Acid Resistant.

E. Sheet Metal and Air Conditioning Contractors:

1.3 SUBMITTALS

A. Agreement for Mechanical and Control Design-Build Project - Submittal Procedures: Submittal procedures.

B. Shop Drawings: Indicate material profile, jointing pattern, jointing details, fastening methods, flashings, terminations, and installation details.

1.4 QUALITY ASSURANCE

A. Thermal Movement: Fabricate and install sheet metal flashings to allow for movement of components without causing buckling, failure of joint seals, undue stress on fasteners or other detrimental effects when subject to 100 year seasonal temperature ranges.

1.5 QUALIFICATIONS

A. Installer: Company specializing in sheet metal work with minimum three years’ experience.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Agreement for Mechanical and Control Design-Build Project - Product Requirements: Product storage and handling requirements.

B. Stack material to prevent twisting, bending, and abrasion, and to provide ventilation. Slope metal sheets to ensure drainage.

C. Prevent contact with materials causing discoloration or staining.

1.7 COORDINATION
A. Coordinate with Work of other Sections requiring flashing and trim components for a complete assembly.

PART 2 – PRODUCTS

2.1 SHEET METAL FLASHING AND TRIM

A. Galvanized Steel: ASTM A653; structural steel sheet, G90 zinc coating; 0.024 inch thick steel.

B. Pre-Finished Galvanized Steel Sheet: ASTM A755; structural steel sheet, G90 zinc coating; 0.024 inch thick core steel, shop pre-coated with fluoropolymer finish as specified in Factory Finishing; color as selected.

C. Pre-Finished Aluminum Sheet: ASTM B209; 3003 alloy, H14 temper; 0.032 inch thick; finish shop pre-coated with fluoropolymer finish as specified in Factory Finishing; color as selected.

D. Lead: ASTM B749, 0.039 inch thick.

E. Stainless Steel: ASTM A240; Type 316, dead soft fully annealed, 0.015 inch thick; smooth surface, smooth surface, Number 4 finish.

F. Copper: ASTM B370; H00 temper except where 060 temper is required for forming, 16 oz. (0.022 inch thick).

2.2 ACCESSORIES

A. Fasteners: Same material and finish as flashing metal. Match finish of exposed heads with material being fastened.

B. Slip Sheet: 5-lb. rosin sized building paper.

C. Primer: Zinc molybdate type for Aluminum, Stainless Steel and Galvanized Steel. Galvanized iron type primer may be used with Galvanized Steel.

D. Protective Backing Paint: Zinc molybdate alkyd or FS TT-C-494, Bituminous.

E. Mastic Sealant: Type E butyl, non-hardening, non-skinning, non-drying, non-migrating sealant. Ultra-violet and ozone resistant.

F. Elastomeric Sealant: Type recommended by manufacturer of metal and fabricator of components being sealed and complying with requirements for joint sealants as specified in Section 07 90 00.

G. Plastic Cement: ASTM D4586, Type I.


I. Solder: ASTM B32.
   1. For use with Steel: 50-50 tin/lead, with rosin flux.
2. For use with Stainless Steel: 60-40 tin/lead, with acid-chloride type flux, except use rosin flux over tinned surfaces.

2.3 FABRICATION

A. Shop-fabricate work to greatest extent possible. Comply with details shown and with applicable requirements of Reference Standards and other recognized industry practices. Fabricate for waterproof and weather-resistant performance, with expansion provisions for running work, sufficient to permanently prevent leakage, damage, or deterioration of the work. Form work to fit substrates. Comply with material manufacturer instructions and recommendations for forming material. Form exposed sheet metal work without excessive oil-canning, buckling, and tool marks, true to line and levels indicated. Apply bituminous paint on concealed surfaces of metal flashings, except where metal flashing will be in contact with incompatible materials (including PVC).

B. Fabricate cleats of same material as sheet metal, interlocking with sheet.

C. Unless indicated otherwise on Drawings, form pieces in longest possible equal lengths up to 10 feet. Hem exposed edges on underside 1/2 inch; miter and seam corners.

D. Non-Moving Joints: Form only non-moving material with sealed flat lock seams or mechanically fasten and solder 1 inch minimum lap or as indicated on Drawings. Neutralize flux after soldering.

E. Expansion Provisions: Use sealed lapped or bayonet-type seams. Where lapped or bayonet-type expansion provisions in Work cannot be used or would not be sufficiently water/weatherproof, form expansion joints of interlocking hooked seams, not less than 1 inch deep, filled with mastic sealant concealed within joints.

F. Fabricate corners from one piece with minimum 18 inch long legs; seam or solder for rigidity, seal with sealant.

G. Fabricate vertical faces with bottom edge formed outward 1/4 inch and hemmed to form drip.

2.4 FACTORY FINISHING

A. Fluoropolymer Coating: Provide where indicated or specified for sheet metal system, thermally cured, conforming to AAMA 2605.

B. Washcoat: Finish concealed side of metal sheets with washcoat compatible with finish system, as recommended by finish system manufacturer.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Division - Administrative Requirements: Coordination and project conditions.

B. Verify roof openings, curbs, pipes, sleeves, ducts, and vents through roof are solidly set, reglets in place, and nailing strips located.
Verify roofing termination and base flashings are in place, sealed, and secure.

3.2 PREPARATION

A. Install starter and edge strips, and cleats before starting installation.

B. Install surface mounted reglets to lines and levels indicated on Drawings. Seal top of reglets with sealant.

C. Paint concealed metal surfaces with protective backing paint to minimum dry film thickness of 15 mil.

D. Where stainless steel or aluminum is to be installed directly on cementitious or wood substrates, install slip sheet and polyethylene underlayment.
   1. Weatherlap joints as recommended by system manufacturer, not less than 2 in. at building paper.
   2. Secure underlayment in place, stagger joints between layers; lap ends minimum 6 inches; stagger end joints.
   3. Apply layer of sheet membrane underlayment extending 18 inches from penetrations, including windows and doors; start at bottom of penetration and weatherlap joints; apply top layer over metal flashing to direct water to exterior.

3.3 INSTALLATION

A. Except as otherwise indicated, comply with manufacturer's installation instructions and recommendations and with Reference Standards. Complete all metal work in conjunction with waterproofing so that a watertight condition exists daily.

B. Insert counterflashings into reglets either by snap-in seal arrangement or by welding in place for anchorage and filling reglet with mastic or elastomeric sealant, as indicated and depending on degree of sealant exposure.

C. Apply plastic cement compound between metal flashings and felt flashings.

D. Fit flashings tight in place. Make corners square, surfaces true and straight in planes, and lines accurate to profiles.

E. Flashings shall have a 4-inch minimum nailing flange or as shown and shall be fastened into solid wood blocking or metal backing with fasteners of the same type with two rows of annular ring nails 4 inches on center staggered. Fasteners shall penetrate wood blocking a minimum of 1-1/4 inch. Anchor flanges to concrete with acceptable concrete anchors 6 inches on center staggered. Bed flanges of Work in thick coat of bituminous roofing cement where required for waterproof performance.

F. Lap expansion joints minimum of 2 inches and seal watertight with plastic cement.

G. Seal metal joints watertight.
H. Provide soldered metal joints with full metal surface contact. After soldering, wash metal clean with neutralizing solution and rinse with water.

3.4 FIELD QUALITY CONTROL

A. Exposed Metal Surfaces: Clean and remove substances that might cause corrosion of metal or deterioration of finishes.

B. Protection: Protect flashings and sheet metal work during construction to ensure that work will be without damage or deterioration other than natural weathering at time of Substantial Completion.

C. Touch up scratched and damaged metal to match new. Remove and replace sheet metal units that cannot be repaired to look identical to adjacent sheet metal when viewed from 15 feet away.

END OF SECTION
PART 1 - GENERAL

1.1 SUMMARY

A. Section includes: Hollow metal steel frames for doors.

B. Related Sections:
   1. Section 07 62 00 – Sheet Metal Flashing and Trim.
   4. Section 09 24 00 – Cement Plastering.
   5. Section 09 90 00 – Painting and Coating: Finish painting.

1.2 References:

A. American National Standards Institute (ANSI):
   1. ANSI A250.8/SDI 100 - Recommended Specifications for Standard Steel Doors and Frames.
   2. ANSI A250.10 - Test Procedure and Acceptance Criteria for Prime Painted Steel Surfaces for Steel Doors and Frames.
   3. ANSI A250.11 - Recommended Erection Instructions for Steel Frames.

B. American Society for Testing and Materials International (ASTM):
   3. ASTM A 569 - Standard Specification for Steel, Carbon (0.15 Maximum, Percent), Hot-Rolled Sheet and Strip Commercial Quality.
   4. ASTM A 620 - Standard Specification for Drawing Steel (DS), Sheet, Carbon, Cold-Rolled.
   5. ASTM E152 - Methods of Fire Tests of Door Assemblies.

C. National Fire Protection Association (NFPA):
D. Steel Door Institute (SDI):
   1. SDI 111 - Recommended Standard Details for Steel Doors & Frames.

E. Underwriters Laboratories Inc. (UL):
   1. UL 10B - Fire Tests of Door Assemblies.
   2. UL 10C - Positive Pressure Fire Tests of Door Assemblies.

1.3 SUBMITTALS

A. No Product Data or Manufacturer Installation Instructions submittals required unless products and systems used deviate from those indicated in Part 2 of this Section.

B. If submittal is required due to product deviation, submit the following items under provisions of Agreement for Mechanical and Control Design-Build Project.

C. Shop Drawings: Indicate frame elevations, reinforcement, anchor types and spacing, location of cut-outs for hardware, and finish.

D. Product Data: Submit frame configuration and finishes.

E. Manufacturer's Installation Instructions: Submit manufacturer's installation instructions.

F. Manufacturer's Certificate: Certify products meet or exceed specified requirements.

1.4 QUALITY ASSURANCE

A. Regulatory Requirements: Comply with applicable requirements of the laws, codes, and regulations of DSA.

B. Fire Rated Frame Construction:
   1. Conform to ASTM E152.
   2. Smoke and draft control assemblies: Comply with UL 10B, Fire Tests of Door Assemblies. Label shall carry a supplemental "S" signifying smoke rating.

C. Installed Frame Assembly:
   1. Conform to NFPA 80 for fire rated class same as fire door.
   2. Smoke and draft assemblies: Comply with UL 10B, Fire Tests of Door Assemblies, and installation instructions for listed assembly.

1.5 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three years documented experience.

1.6 DELIVERY, STORAGE, AND HANDLING
A. Agreement for Mechanical and Control Design-Build Project- Product Requirements: Product storage and handling requirements.

B. Accept frames on site in manufacturer's packaging. Inspect for damage.

C. Break seal on-site to permit ventilation.

1.7 COORDINATION

A. Agreement for Mechanical and Control Design-Build Project– Administrative Requirements: Coordination and project conditions.

B. Coordinate Work with frame opening construction, door, and hardware installation.

C. Sequence installation to accommodate required door hardware electric wire connections.

PART 2 - PRODUCTS

2.1 STANDARD STEEL FRAMES

A. Manufacturers: Furnish compliant products of one of the following or approved equal:
   1. Curries Company
   2. Door Components, Incorporated.
   3. Steelcraft.
   4. Stiles Custom Metal, Incorporated.

B. Product Description: Standard shop fabricated steel frames, fire rated and non-rated types. Cold-rolled or hot-rolled steel sheet; not less than 14-gauge.

2.2 ACCESSORIES

A. Removable Stops: Rolled steel channel shape, butted corners; prepared for countersink style tamper proof screws.

B. Mullion Stirrups and Clips: Manufacturer’s standard to suit mullion profile.

C. Bituminous Coating: Non-asbestos fibered asphalt emulsion.

D. Primer: Primer compatible with finish paint system. ANSI A250.10 rust inhibitive type.

E. Silencers: Specified in Section 08 71 00.

F. Weatherstripping: Specified in Section 08 71 00.

2.3 FABRICATION

A. Provide fully-welded units with integral trim, of sizes and shapes shown. Face-welded and Knocked-down frames not accepted.
B. Fabricate frames with hardware reinforcement plates welded in place. Provide mortar guard boxes.

C. Reinforce frames wider than 48 inches with roll formed steel channels fitted tightly into frame head, flush with top.

D. Prepare frames for silencers. Omit at fire-rated doors.

E. Fabricate fire rated and smoke and draft assembly metal frames of materials in accordance with requirements of the listing label. Place labels where visible when frames are installed in position.

F. Finished Work: Strong and rigid, neat in appearance, square, true and free of defects, warp or buckle. Fabricate molded members clean cut, straight and of uniform profile throughout their lengths.

G. Jamb Depths, Trim, Profile, Returns, and Backbends: Depths and profiles to match existing. Double return backbends typical.

H. Corner Joints: Solid interlocking with 16 gauge concealed corner clip reinforcing. Close contact edges tight, hairline miter edges, and butt stops.

I. Stops: Minimum depth 5/8-inches.

J. Hardware Reinforcements:
   1. General: Mortise, reinforce, drill, and tap frames at factory for fully templated mortised hardware only, per hardware schedule and templates provided by hardware supplier. Where surface-mounted hardware is to be applied, provide frames with reinforcing plates only.
   2. Hardware Reinforcing Plates: Minimum thickness as follows:
      b. Strike Reinforcements: 12 gauge.
      c. Flush Bolt Reinforcements: 12 gauge.
      d. Closer Reinforcements: 12 gauge.
      e. Surface-Mounted Hardware Reinforcements: 12 gauge.
      f. Hold-Mounted Hardware Reinforcements: 12 gauge.
      g. Surface Exit Device Reinforcements: 12 gauge.

K. Floor Anchors:
   1. General: Securely weld inside each jamb, with minimum two holes provided at each jamb for base anchorage.
   2. Adjustable Anchors: Where so scheduled or specified, provide adjustable floor anchors, not less than 2 inches in height adjustment.
   3. Thickness: Minimum 14 gauge.
L. Jamb Anchors:
   1. Stud Partitions: Provide frames with steel anchors of suitable design, not less than 16-gauge thickness, securely welded inside each jamb as follows:
      a. Frames up to 7'-6" height: 4 anchors.
      b. Frames 7'-6" to 8'-0" height: 5 anchors.
      c. Frames over 8'-0" height: 5 anchors plus one additional for each 2'-0" or fraction thereof over 8'-0".

M. Steel Spreader: Provide frames with steel spreader attached to feet of both jambs to serve as temporarily brace during installation.

2.5 SHOP FINISHING

A. Surface Preparation: Clean surfaces to comply with SSPC-SP 1, “Solvent Cleaning”; remove dirt, oil, grease, or other contaminants that could impair paint bond. Remove mill scale and rust, if present, form uncoated steel, complying with SSPC-SP 3, “Power Tool Cleaning”, or SSPC-SP 6/NACE No. 3 “Commercial Blast Cleaning”.

B. Factory Priming for Field-Painted Finish: Apply manufacturer’s standard rust-inhibitive primer immediately after surface preparation and pretreatment. Apply primer to a uniform dry film thickness of not less than 0.7-mils. Fully cure before shipment.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Agreement for Mechanical and Control Design-Build Project – Administrative Requirements: Coordination and project conditions.

B. Verify opening sizes and tolerances are acceptable.

C. Verification of Conditions: Examine substrate and conditions under which hollow metal frames are to be installed and give notification, in writing, of any conditions detrimental to proper and timely completion of work. Do not proceed with work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install frames in accordance with ANSI A250.8 and NFPA 80 for fire rated frames.
   1. Install smoke and draft control assemblies in accord with the requirements of the label.
   2. Install frames in accordance with manufacturer’s printed instructions for fire rated frames.

B. Coordinate with gypsum board wall construction for anchor placement.

C. Setting: Exercise care in setting of frames to maintain scheduled dimensions, hold head level, and maintain jambs plumb and square.
D. Anchorages and Connections: Secure to adjacent construction. Furnish anchors to suit wall conditions or clips welded to frame for fastening to structure.

E. Spreader Bars: Whenever possible, leave frame spreader bars intact until frames are set perfectly square and plumb and anchors are securely attached.

F. Expansion Movement: Allow for as required.

G. Coordinate installation of frames with installation of hardware.

H. Install roll formed steel reinforcement channels between two abutting frames. Anchor to structure.

I. Ensure that frames are securely and rigidly anchored to adjacent construction.

J. Install side light and window frames with formed glass stops on room side. Coordinate the installation of glass and glazing.

K. After installation, touch up scratched or damaged surfaces. Use type of primer identical to that used for shop coat.

3.3 ERECTION TOLERANCES

A. Agreement for Mechanical and Control Design-Build Project - Quality Requirements: Tolerances.

B. Maximum Diagonal Distortion: 1/8 inch measured with straight edges, crossed corner to corner.

3.4 FIELD FINISHING

A. General: Immediately after installation remove rust, sand smooth, and touch-up items with prime coat which has been damaged with same primer as applied in shop. Meet all local VOC regulations.

B. Finish Painting: Apply finish paint per Section 09 90 00.

END OF SECTION
PART 1 – GENERAL

1.1 SUMMARY

A. Section includes provision of steel doors and installation of their hardware.

B. Related Sections:
   1. Section 08 12 14 - Standard Steel Frames.
   2. Section 09 90 00 - Painting and Coating: Field painting of doors.

1.2 REFERENCES

A. American National Standards Institute (ANSI):
   1. ANSI A250.8 / SDI 100 - Recommended Specifications for Standard Steel Doors and Frames.

B. ASTM International (ASTM):
   1. ASTM A653 - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.

C. Intertek Testing Services (Warnock Hersey Listed):
   1. WH - Certification Listings.

D. National Fire Protection Association (NFPA):
   2. NFPA 105 – Standard for the Installation of Smoke Door Assemblies and Other Opening Protectives.

E. Underwriters Laboratories Inc. (UL):
   1. UL - Building Materials Directory.
   2. UL 10B - Fire Tests of Door Assemblies.
   3. UL 10C - Positive Pressure Fire Tests of Door Assemblies.
1.3 SUBMITTALS

A. Agreement for Mechanical and Control Design-Build Project - Submittal Procedures: Requirements for submittals.

B. Shop Drawings: Indicate door elevations, internal reinforcement, closure method, and cut-outs for glazing, louvers, and finishes.

C. Product Data: Submit door configurations, location of cut-outs for hardware reinforcement.

D. Manufacturer's Installation Instructions: Submit special installation instructions.

E. Manufacturer's Certificate: Certify products meet or exceed specified requirements.

1.4 QUALITY ASSURANCE

A. Perform Work in accordance with ANSI A250.8.

B. Steel doors shall be the product of the same manufacturer to insure uniformity of quality and appearance throughout the project.

C. Fire Rated Door Construction:
   1. 20-Minute Fire-Rated Corridor Doors: As part of a fire tested assembly in accordance with NFPA 252 or UL 10C without the hose stream test. Assembly shall be gasketed and meet smoke and draft control requirements in accordance with UL 1784.
   2. 45-Minute Special Use Room Doors: As part of a fire tested assembly in accordance with NFPA 252, UL 10B or UL 10C with the hose stream test.
   3. 60- and 90-Minute Exit Stair and Exit Passageway Doors: As part of a fire tested assembly in accordance with NFPA 252 or UL 10C with the hose stream test.

D. Installed Fire Rated Door Assembly: Conform to NFPA 80 for fire rated class as indicated on Drawings.

E. Installed Smoke and Draft Control Door Assembly: Conform to NFPA 105.

F. Attach WH-Certification or label from other agency approved by authority having jurisdiction to identify each fire rated door.
   1. Smoke and Draft Control Door Assemblies: Include the letter “S” on the label.

1.5 QUALIFICATIONS

A. Manufacturer and Installer: Companies specializing in manufacturing and installing products specified in this section with minimum three years’ documented experience.

1.6 DELIVERY, STORAGE, AND HANDLING
A. Agreement for Mechanical and Control Design-Build Project - Product Requirements: Requirements for transporting, handling, storing, and protecting products.

B. Accept doors on site in manufacturer's packaging. Inspect for damage.

C. Do not store in damp or wet areas. Break seal on site to permit ventilation.

1.7 COORDINATION

A. Agreement for Mechanical and Control Design-Build Project - Administrative Requirements: Requirements for coordination.

B. Coordinate Work with door opening construction, door frame, and door hardware installation.

C. Coordinate installation to accommodate door hardware electric wire connections.

PART 2 – PRODUCTS

2.1 STANDARD STEEL DOORS

A. Manufacturers: Furnish compliant products of one of the following or approved equal:
   1. Curries Company
   2. Door Components, Incorporated.
   3. Steelcraft.
   4. Stiles Custom Metal, Incorporated.

B. Product Description:
      a. Level 3 - Extra heavy Duty, Model 2, seamless design.
      b. Galvanized steel faces, end closures, and internal components.

2.2 COMPONENTS

A. Face: Steel sheet in accordance with ANSI A250.8/SDI 100.

B. End Closure: Cold-rolled channel, flush orientation.

C. Core: Chemically-inert, moisture-resistant as recommended by door manufacturer.

D. Thermal Insulated Door: Total insulation minimum R-Value of 2.4, measured in accordance with ASTM C1363.

2.3 FABRICATION

A. Fabricate doors with hardware reinforcement welded in place.
2.4 SHOP FINISHING
   A. Steel Sheet: Galvanized to ASTM A653 G60 or G90.
   B. Primer: ANSI A250.10 rust inhibitive type.

PART 3 – EXECUTION

3.1 EXAMINATION
   A. Agreement for Mechanical and Control Design-Build Project - Administrative Requirements: Verification of existing conditions before starting work.
   B. Verify opening sizes and tolerances are acceptable.

3.2 INSTALLATION
   A. Install doors in accordance with ANSI A250.8.
      1. Install smoke and draft control assemblies in accord with the requirements of the label.
      2. Install doors in accordance with manufacturer’s printed instructions for fire rated doors.
   C. Coordinate installation of doors with installation of frames specified in Section 08 12 14 and hardware to match campus standards.

3.3 ERECTION TOLERANCES
   A. Agreement for Mechanical and Control Design-Build Project - Quality Requirements: Tolerances.
   B. Maximum Diagonal Distortion: 1/8 inch measured with straight edge, corner to corner.

3.4 FIELD FINISHING
   A. General: Immediately after installation remove rust, sand smooth, and touch-up items with prime coat which has been damaged with same primer as applied in shop. Meet all local VOC regulations.
   B. Finish Painting: Apply finish paint per Section 09 90 00.

3.5 ADJUSTING
   A. Agreement for Mechanical and Control Design-Build Project - Execution and Closeout Requirements: Requirements for adjusting.
   B. Adjust door for smooth and balanced door movement.

END OF SECTION
PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Metal stud partition framing.
   2. Miscellaneous interior light gauge framing.
   3. Gypsum board panel product, installation and finish on walls and ceilings, including joint treatment.

B. Related Sections:
   1. Section 05 40 00 - Cold-Formed Metal Framing: Exterior stud wall framing system.
   2. Section 05 50 00 – Metal Fabrications: Expansion anchors & miscellaneous supports for framing.
   3. Section 08 12 14 - Standard Steel Frames: Coordination with Gypsum Board Assemblies.
   4. Section 09 90 00 - Paints and Coatings: Surface finish and primer/sealer.

1.2 REFERENCES

A. American Society for Testing and Materials (ASTM):
   1. ASTM C475 - Specification for Joint Compound and Joint Tape for Finishing Gypsum Board.
   2. ASTM C645 - Non-Load Bearing (Axial) Steel Studs, Runners (Track), and Rigid Furring Channels for Screw Application of Gypsum Board.
   3. ASTM C754 - Installation of Steel Framing Members to Receive Screw-Attached Gypsum Board.
   5. ASTM C1002 - Specification for Steel Self-Piercing Tapping Screws for the Application of Gypsum Panel Products to Wood or Steel Studs (less than 0.033 inch in thickness).

B. California Building Code (CBC).

C. Gypsum Association (GA):
   1. GA-201: Gypsum Board for Walls and Ceilings.
   3. GA-216: Recommended Specifications for Application and Finishing of Gypsum Board.

D. ICC Evaluation Service:
   1. International Code Council Evaluation Service Reports as referenced herein.

E. Federal Specifications:
   1. United States General Services Agency Federal Specifications and Commercial Item Description reports as referenced herein.

F. Underwriters Laboratories, Inc. (UL):

G. Warnock Hersey (WH):
   1. Certification Listings.

1.3 PERFORMANCE REQUIREMENTS

A. Conform to applicable code for fire rated assemblies as follows:
   1. Fire Rated Partitions: Listed assembly by UL as shown, and as required to complete gypsum board assemblies against abutting assemblies.
   2. Fire Rated Structural Column Framing: Listed assembly by UL or WHI.
   3. Fire Rated Structural Beam Framing: Listed assembly by UL or WHI.
   4. Fire Rated Shaft Wall Requirements: 1- and 2-hour in accordance with UL or WHI.

1.4 SUBMITTALS

A. Agreement for Mechanical and Control Design-Build Project - Submittal Procedures: Submittal procedures.
B. Product Data: Submit manufacturer’s literature and installation instructions for each material and accessory. Clearly identify specified sizes and options intended to be furnished.

1.5 QUALITY ASSURANCE
A. Perform Work in accordance with the referenced documents listed above.
B. Regulatory Requirements: Comply with applicable requirements of the laws, codes, and regulations of Authority Having Jurisdiction.

1.6 QUALIFICATIONS
A. Installer: Company specializing in performing Work of this section with minimum five years documented experience.

1.7 DELIVERY, STORAGE, AND HANDLING
A. Storage and Protection: Store materials inside under cover and stacked flat. Stack gypsum board so that long lengths are not over short lengths.

1.8 PROJECT/SITE CONDITIONS
A. Temperature: Maintain temperature range between 55 degrees and 70 degrees F for 24 hours before, during and after gypsum board and joint treatment application.
B. Ventilation:
   1. Provide ventilation during and following adhesive and joint-treatment applications.
   2. Use temporary air circulators in enclosed areas lacking natural ventilation.
   3. Under slow drying conditions, allow additional drying time between coats of joint treatment.

PART 2 - PRODUCTS
2.1 PARTITION AND RIGID CEILING FRAMING MATERIALS
A. Manufacturers: Furnish compliant products of one of the following, or approved equal.
   1. California Expanded Metal Products Company / CEMCO.
   2. ClarkDietrich Building Systems LLC.
   3. SCAFCO Corporation.
B. Studs, Joists and Tracks: ASTM C645 and GA-600, galvanized steel sheet, 16 gauge unless otherwise indicated on Drawings.
   1. Material:
18-Gauge and Lighter: ASTM A570, Grade C, steel sheet with corrosion resistant factory finish, 33 ksi yield strength.

16-Gauge and Heavier: ASTM A570, Grade E, steel sheet with corrosion-resistant factory finish, 50 ksi yield strength.

2. Studs and Joists: Non-bearing "cee" type with punched webs and flanges not less than 1-3/8 inches wide, depth as indicated.

3. Track: Steel sheet channel with unpunched webs and flanges not less than 1-1/2 inches wide. Depth as indicated and/or to match interfacing studs or joists.


5. Slotted Steel Track: Same gauge, depth and finish as interfacing metal studs unless otherwise shown. Sliptrack Systems’ “SLP-TRK”, Metal-Lite’s “The System”, Scafco’s “Slotted Track”, or equal.

6. Backing Plates and Bracing Straps: 20-gauge steel sheet unless otherwise shown, same finish as interfacing metal studs, and sizes as shown.

2.2 MISCELLANEOUS FRAMING MATERIALS

A. Clips and Clip Angles: 20-gauge steel sheet, unless otherwise shown, same finish as interfacing metal studs, and sizes and shapes as shown.

B. Fasteners: Hot-dip galvanized at exterior assemblies and at pressure-treated lumber unless indicated otherwise on drawings.
   2. Powder-actuated fasteners: 0.157-inch shank diameter, 1-1/4 inch length unless otherwise noted on Drawings.
   3. Expansion Anchors: Refer to 05 50 00 – Metal Fabrications.
   4. Welding: In conformance with AWS D1.1 and AWS D1.3.
   5. Welding Electrodes: AWS, low hydrogen type, as required.

C. Miscellaneous Framing Accessories: Manufacturer's standard, suitable for use intended.

2.3 GYPSUM PANEL MATERIALS

A. Manufacturer: Compliant products of one of the following, or approved equal. Products of Georgia-Pacific are listed below as the specified basis.
   1. Celotex Building Products.
   2. Georgia-Pacific Corporation.
B. Gypsum Board: Paper-faced ASTM C1396, fire-resistive type throughout unless otherwise shown or specified. 5/8-inch thick or as indicated, maximum available length in place; tapered edges. “ToughRock Fireguard”.

C. Moisture-Resistant Gypsum Board: Fiberglass mat-faced ASTM C1658, fire-resistive type where indicated. Mold-resistant and paintable. 5/8-inch thick or as indicated, maximum available length in place. “DensArmor Plus High Performance Interior Panel”.

D. Gypsum Tile Backer Board: Fiberglass mat-faced ASTM C1178 when furnished in 5/8” thickness, anti-microbial, built-in moisture barrier and moisture-resistant core. ANSI A118.9-compliant. 5/8-inch thick or as indicated, maximum available length in place. “DensShield Tile Backer”.

E. Gypsum Sheathing: ASTM C1177; fiberglass mat-faced gypsum core, 5/8 inch thick or as indicated, maximum available length in place. “DensGlass Gold”.

F. Fasteners: ASTM C1002, Type S, Philips head bugle shape screws. Provide rust-resistant at Gypsum Tile Backer Board and Gypsum Sheathing. Sizes as required by code and as recommended by gypsum panel manufacturer.

2.5 ACCESSORIES

A. Blanket (Batt) Thermal and Acoustic Insulation at exterior stud cavities in thickness and R-value to match existing.

B. Acoustic Sealant: Where required to maintain acoustic separation of spaces.

C. Corner Beads: Galvanized or aluminum.

D. Edge Trim: GA-216; Type LC bead, galvanized or aluminum.

E. Control Joints: Miscellaneous factory-primed aluminum extrusions suitably finished for field painting with acrylic latex paint. Reveal width as indicated. Extrusions shall feature fins suitable for screw anchorage and finished over with tape and joint compound. Control Joints shall include concealed continuous compression seals. Pittcon “Softforms”, Fry Reglet “Reveal Molding”, or equal.

F. Gypsum Board Joint Materials:
   2. Joint Compounds: ASTM C475, ready-mix, non-asbestos, vinyl formulation joint compound. At moisture resistance gypsum board, use joint compound for water-resistant board.
   3. Adhesive: Laminating Adhesive: Special adhesive or joint compound recommended for laminating gypsum base panels to face panels in multilayer construction.

G. Outlet Box Pads used for Fire-Rated or Acoustical purposes – Where required to maintain fire-rated or acoustic separations.

I. Sound Isolation Clips: Engineered with resilient isolation material for installation on steel wall studs and application of horizontal furring channels. Listed with UL for optional use on fire-resistive wall assemblies to two-hour minimum. Furnish one of the following or approved equal:

1. Kinetics Noise Control, Incorporated’s “Isomax”.
2. Pliteq, Incorporated’s “Genie Clip”.
3. PAC International, Incorporated’s “RSIC-1”.

J. Miscellaneous Items: Provide components not specified but shown and provide other items and accessories required for complete installation.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Agreement for Mechanical and Control Design-Build Project – Administrative Requirements: Coordination and project conditions.

B. Verify site conditions are ready to receive work and opening dimensions are as instructed by manufacturer.

3.2 GENERAL

A. Install Work plumb, level, true, straight and rigid per reference standards, manufacturer’s recommendations, and as specified.

B. Tolerances: Do not vary from true plane greater than 1/8-inch in 8 feet, measured in any direction.

C. Do not bridge building expansion or seismic joints with framing or furring members. Independently frame both sides of joints with framing or furring members.

D. Frame and reinforce openings for doors, windows, ducts, access panels, and other openings and items as shown or per referenced standards.

E. Install accessories and miscellaneous specialties plumb, true and level. Install other materials and items as required as part of the Work of other Sections.

F. Install and tighten expansion anchors in accordance with manufacturer’s recommendations and referenced Reports. Coordinate for inspection and testing as required. Clean and repair surfaces damaged by drilling or installation and fill abandoned holes with patching mortar in accordance with the manufacturer’s instructions. Correction of defective work shall be the responsibility of the Design Builder.

3.3 INTERIOR WALL AND PARTITION INSTALLATION
A. Frame from floor to structure above with metal studs at 16 inches on center, unless otherwise shown.
   1. Fasten floor track and slotted top track to structure as shown, 2 inches from ends and with spacing not to exceed that of studs.
   2. Secure metal studs in tracks with sheet metal screws as indicated. Fasten studs to slotted top tracks through centers of slotted holes as shown.

B. Brace studs as shown, including at locations that will not receive gypsum panels.

C. Provide backing as scheduled and detailed and of sufficient length to fasten each end to metal framing. Provide backing support for each point of fastening of every unit to be anchored.

D. Resilient Channel: Attach resilient channels, where required, on 16-inch centers perpendicular to stud framing.
   1. Drive screws only through pre-punched holes in channels.
   2. Attach resilient channels with mounting flanges facing in only one direction. Orient the gap between the channel and stud faces upward on walls.
   3. Hold back ends of channels 1/2 to 3 inches from intersecting surfaces.
   4. Splice channels only at studs and overlap ends by not more than 1-1/2 inches.
   5. Locate channels so that gypsum board will not be cantilevered more than 6 inches from vertical surfaces.

3.4 ACOUSTIC ACCESSORIES INSTALLATION:

A. Place acoustic insulation in partitions tight within spaces, around cut openings, behind and around electrical and mechanical items within or behind partitions, and tight to items passing through partitions.

B. Install Outlet Box Pads at all boxes within partitions identified as fire-rated or acoustical.

3.5 GYPSUM PANEL INSTALLATION (INTERIOR):

A. General: Comply with applicable requirements of specified reference standards, except where more stringent requirements are specified; mandated by local codes; or by manufacturer of gypsum board.
   1. End Joints: Neatly fit and stagger.
   2. Joints: Locate on different studs at opposite sides of partition.
   3. Workmanship: Install Work with plumb and straight surfaces, with no waves or buckles, and free of unevenness at joints.

B. Ceilings:
   1. General: Apply gypsum board with long dimension at right angles to horizontal supports.
   2. End Joints: Provide with solid bearing.
C. Partitions:
   1. General: Apply gypsum board with long dimensions perpendicular to studs and with all abutting edges over supports.
      a. Start application at corner of room or space.
      b. Stagger joints to occur on different framing members on opposite sides of partitions wherever possible.
      c. Do not place butt ends against tapered edges.
      d. Cut, fit neatly around outlets, switches, and other penetrating items.
      e. Cut gypsum board to not more than 1/4-inch of penetrating ducts, pipes, conduit, outlet boxes, and other penetrating items.

D. Fastening:
   1. Attach gypsum board with specified fastener type. Space fasteners per more stringent of specified Reference Standards or UL standards. Stagger opposite each other on adjacent ends or edges.
   2. Drive screws with power screwdriver recommended by gypsum board manufacturer. Do not hammer-drive screws.
   3. Set fastener head slightly below surface of gypsum board. Do not break through facing surface of gypsum board.
   4. Omit fasteners at edges where metal edge trim will be installed.
   5. When furring channels are used with sound isolation clips, attach gypsum board to furring channel only. Do not allow gypsum screws to contact studs.

E. Double-Layer Installation:
   1. Install first layer per requirements specified above and finish to Level 2 as specified below.
   2. Screw fasten second layer similarly. Orient second layer of panels in either direction. Stagger joints and abut vertical joints over studs.

F. Metal Trim:
   1. General: Apply trim at exterior corners and at interior corners where gypsum board intersects metal or other dissimilar materials.
   2. Trim Lengths: Install in longest lengths practicable.
   3. Trim: Run straight and square with planes.
   4. Edges: Apply applicable shape metal edge trim at exposed edges of gypsum board and where otherwise shown. Where gypsum panel abuts other materials, install edge trim with 1/8-inch clearance to allow for caulking, unless otherwise shown.
   5. External Corners: Apply cornerbeads at external corners and where otherwise shown in single lengths.
6. Install control joints as indicated. Install straight, level and plumb. Align with corners of openings and other elements. Confirm with Architect the requirements for control joints where not indicated at continuous gypsum board surfaces 30 feet or greater in length.

G. Perimeters, Penetration, and Openings: Seal all perimeter material transitions, penetrations, outlet boxes, and openings.

1. Acoustic Partitions: Install Acoustic Sealant and install and seal other gaps per requirements on drawings and as specified in Section 07 90 00.
2. Fire-Rated Partitions: If partition is fire-rated, install fire-stopping in lieu of acoustic sealant as specified in Section 07 84 00.

3.6 GYPSUM PANEL TAPING AND FINISHING:

A. Level 1: Provide in plenums, attics, and other concealed areas. All joints and interior angles shall have tape set in joint compounds. Surface shall be free of excess joint compound. Tool marks and ridges are acceptable.

B. Level 2: Not Used.

C. Level 3: Not Used.

D. Level 4: Provide in areas where flat and eggshell paints, light textures, or wall coverings are to be applied. All joints and interior angles shall have tape embedded in joint compound and two separate coats of joint compound applied over all flat joints and one separate coat of joint compound applied over interior angles. Fastener heads and accessories shall be covered with three separate coats of joint compound. All joint compounds shall be smooth and free of tool marks and ridges.

E. Level 5: Provide at locations where indicated and at all locations scheduled to receive paints with semi-gloss and gloss sheen as defined under Section 09 90 00. Finish gypsum board, after taping and finishing specified under Level 4 above, as follows.

1. Apply a thin skim coat of joint compound to entire surface of gypsum board. Apply in manner to minimize suction, porosity, and other surface variations between joint compound and face paper surface. Take special care to eliminate lap and tool marks during application.

F. General: Apply joint compound and joint tape per manufacturer’s directions.

G. Acoustical Sealant: Do not apply joint tape and joint compound over joints containing acoustical sealant until sealant has completely cured.

H. Tape: Center tape over joints and embed in uniform layer of joint compound of sufficient width and depth to provide form and complete bond.

1. Apply skim coat while embedding tape.
2. At Moisture Resistant Gypsum Board and Tile Backer Board, fill fastener heads, penetrations, and joints with water-resistant compound.

I. Angles: Treat with joint tape folded to conform to adjacent surfaces and straight, true angles.
J. Drying Time: Provide minimum 24 hours between applications of compound.

K. Finishing Compound: Apply coat over joint compound and tape.
   1. Spread evenly and feather out beyond edge of board.
   2. After first finishing coat is thoroughly dry, cover with second coat with edges feathered out slightly beyond the preceding coat.
   3. Apply third coat if required to visually conceal gypsum board joints.

L. Fastener Depressions: Give dimples at fastener heads and marred spots on surface of gypsum board one coat joint compound and two coats finishing compound. Apply in same manner as for joints.

M. Metal Trim: Conceal flanges with minimum two coats compound. Extend compound 8 to 10 inches each side of metal nosing.

N. Sanding: After each application of joint or finishing compound has dried, lightly sand joints. Leave gypsum board and treated areas uniformly smooth and ready for painting or other decoration.

3.7 GYPSUM SHEATHING INSTALLATION:

A. General: Comply with ASTM C1280, GA-253 and manufacturer's written instructions, except where more stringent requirements are specified; mandated by local codes; or by manufacturer of gypsum board.

B. Orient sheathing vertically (parallel with framing) and abut ends and/or edges of the boards centered over face of framing members. Offset board joints by not less than one stud spacing.

C. Cut panels at penetrations, edges, and other obstructions of work; fit closely against abutting construction unless otherwise indicated.

D. Coordinate sheathing installation with flashing and joint-sealant installation so these materials are installed in sequence and manner that prevent exterior moisture from passing through completed assembly.

E. Do not bridge building expansion or deflection joints; cut and space edges of panels to match spacing of supporting elements.

F. Install boards with a 1/4-inch gap where they abut concrete or similar material that might retain moisture, to prevent wicking. Install with a 3/8-inch gap where structural elements, plumbing and conduit penetrate sheathing, unless otherwise noted. Seal all gaps per Division 7.

G. Fasten sheathing to cold formed metal framing with screws with power screwdriver recommended by gypsum board manufacturer. Do not hammer-drive screws. Locate fasteners not less than 3/8 inch from ends and edges of sheathing, spaced at 4 inch centers along vertical sides and 8 inch centers along intermediate supports. Set fastener heads at or slightly below surface of sheathing.

END OF SECTION
SECTION 09 24 00

CEMENT PLASTERING

PART 1 – GENERAL

1.1 SUMMARY

A. Section includes Portland cement plaster system with acrylic-modified finish, including building paper, lath and accessories for patching at exterior repairs.

B. Related Sections:
   1. Section 05 40 00 - Cold-Formed Metal Framing: Structural metal studding and framing behind plaster base.

1.2 REFERENCES

A. ASTM International:

B. Federal Specification Unit:

1.3 SUBMITTALS

A. Agreement for Mechanical and Control Design-Build Project - Submittal procedures.

B. Product Data: Submit data on each lathing material and accessory, plaster materials, and characteristics and limitations of products specified. Include proposed method for curing scratch coat.
C.
Shop Drawings: Indicate locations of proposed control and expansion joints where not indicated on Drawings.

D.
Samples: Submit 12 x 12 inch in size illustrating finish color and texture.

1.4 QUALITY ASSURANCE

A.
Perform Work in accordance with ASTM C926. Obtain Architect’s approval of scratch coat curing methodology via Submittal process.

B.
Qualified Manufacturer and Installer: Companies specializing in manufacturing products specified in this section with minimum five years’ experience.

1.5 ENVIRONMENTAL REQUIREMENTS

A.
Agreement for Mechanical and Control Design-Build Project - Product Requirements.

B.
Do not apply plaster unless minimum ambient temperature of 40 degrees F has been and continues to be maintained for minimum 48 hours prior to application and until plaster is cured.

C.
Take precautionary measures to ensure plaster is not subjected to excessive sun and wind which could cause uneven and excessive evaporation, premature dehydration, or cracking. Provide opaque tarpaulins or other temporary means of protection when weather conditions warrant.

1.6 WARRANTY

A.
General: Warranties shall pay for all costs associated with repairs and replacement upon notification of defects.

B.
Material Warranty: Manufacturer shall warrant cement plaster and acrylic finish products bearing its name on the label against defects regardless of the source of manufacture.

PART 2 – PRODUCTS

2.1 CEMENT PLASTER

A.
Manufacturers: Furnish compliant products of one of the following or approved equal:

1. BMI Products of Northern California, Incorporated.
2. Senergy, A Division of BASF Wall Systems.
3. STO Corporation.

B.
System Description: An engineered cement-lime-sand mixture with reinforcing fibers for use as the scratch and brown coats in accordance with ASTM C926. Pre-blended, flexible acrylic finish coat mixture with integral color and texture. Basis of Specification: BMI Products’ “690 Plaster” and acrylic finish.

2.2 COMPONENTS:
A. Plaster Base Materials: Provide either a pre-mixed, engineered material or field mixed material, at Design Builder’s option, complying with ASTM C926 and below.
   2. Lime: ASTM C206, Type S.
   4. Fiber: 1/2 inch nominal length glass fibers meeting requirements of ASTM C1116.
   5. Water: Clean, fresh, potable and free of mineral or organic matter capable of affecting plaster.
   6. Scratch and Brown Coat Admixture: Acrylic integral bonding agent type, specifically manufactured for use in Portland cement plastering applications and which will not detrimentally affect finish.
      a. Manufacturers:
         i. Larsen Products Corporation’s “Acrylic Admix 101”.
         ii. Thoro Consumer Products / BASF “Acryl 60”.
         iii. ChemMasters Corporation’s “Cretelox”.

B. Plaster Finish Materials:
   1. Primer: Water-based, 100% acrylic recommended by acrylic finish manufacturer.
   2. Finish: Cement plaster manufacturer’s 100 percent acrylic resin with integral color and texture.
      a. Color: To be selected.

2.3 ACCESSORIES

A. Backing Material: FS UU-B-790 Grade D, building paper.

B. Furring and Lathing: Furnish accessories of one of the following or approved equal.
   1. Cemco.
   2. ClarkDietrich Building Systems.
   3. Fry Reglet Corporation.
      a. Furnish accessories as specified and indicated on the drawings to match the following:
         i. Expanded Metal Lath: ASTM C847, galvanized, diamond mesh, self-furring to hold face 1/4 inch from backing, not less than 3.4 pounds per square yard.
         ii. Casing Bead: ASTM C1047; formed zinc, No. 66X profile, depth governed by plaster thickness, maximum possible lengths, expanded metal flanges, with square edges.
Corner Bead: ASTM C1047; formed zinc, No. 1A profile, depth governed by plaster thickness, maximum possible lengths, expanded metal flanges with straight edge.

Base Sill Screed: ASTM C847; formed galvanized sheet steel, No. 36 profile, depth governed by plaster thickness, maximum possible lengths, solid flanges, weep holes, without full return below edge.

Strip Mesh: Expanded metal lath, minimum 0.018 inch thick, 2 inch wide x 24 inch long; galvanized.

Control Joint Accessories: ASTM C1047; formed zinc, No. 15 accordion (“Double-V”) profile, 2 inch expanded metal flanges each side.

Channel Screed: Single piece, extruded 6063 T5 aluminum alloy. Depth governed by plaster thickness, reveal width as indicated on Drawings, maximum possible lengths, mill finish.

“X” Corner Molding: Single piece, extruded 6063 T5 aluminum alloy to form “negative” outside corners. Depth governed by plaster thickness.

Anchorage: Tie wire, nails, and other metal supports, of type and size to suit application; to rigidly secure materials in place, galvanized.

Fasteners: ASTM C1002, self-drilling, self-tapping Type S screws.

2.4 MIXES

A. Base Coats: For field-mixed material, mix and proportion cement plaster base coat in accordance with ASTM C926 as appropriate for the substrate indicated and the approved samples.

1. Fiber Reinforcement: Add glass fibers to base coats at rate of 3 to 4 ounces per 94 lb sack of cement.

B. Mix only as much plaster as can be used prior to initial set.

C. Add color pigments to finish coat.

D. Mix materials dry, to uniform color and consistency, before adding water.

E. Protect mixtures from freezing, frost, contamination, and excessive evaporation.

F. Do not re-temper mixes after initial set has occurred.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Ensure all wall framing, installation of utilities and other accessories to be installed in wall cavity are complete and inspected prior to covering with cement plaster work. Furnish additional framing and backing required for proper securement of plaster accessories, including vertical joints and reveals.

3.2 PREPARATION
A. General: Clean surfaces to receive plaster. Remove loose materials and other deleterious substances with may impair work.

B. Do not conceal air barrier until field quality control inspections and corrective work is complete.

### 3.3 INSTALLATION

A. Isolation: Isolate lathing and metal support system where it abuts building structure horizontally, and where partition/wall work abuts overhead structure, to prevent transfer of building loads into plaster.

B. Installation of Lathing Materials:
   1. Apply one layer of Grade D building paper over air barrier and substrate; lap edges horizontally in waterfall arrangement, 2 inches minimum. Fasten in place.
   2. Install metal lath in accordance with ASTM C1063. Apply lath taut, with long dimension perpendicular to supports; secure end laps with tie wire where they occur between supports; lap sides minimum 1-1/2"; secure with tie wires.
   3. Place strip mesh diagonally at corners of lathed openings. Secure rigidly in place.
   4. Place strip mesh at junctions of dissimilar materials; place parallel with dissimilar materials; secure rigidly in place.

C. Installation of Accessories:
   1. Install accessories in accordance with ASTM C1063.
   2. Place corner bead at external wall corners; fasten at outer edges of lath only at maximum 12 inches on center.
   3. Place casing beads at terminations of plaster finish. Use single length of metal beads wherever length of run does not exceed longest standard stock length available; miter or cope corners. Butt and align ends. Secure rigidly in place.
      a. Provide casing beads where plaster abuts dissimilar construction and at perimeter of openings where edges of plaster will not be concealed by other work.
   4. Install door and glazed frames plumb and level in opening. Secure rigidly in place.
   5. Install sill and drip screeds with paper sheathing and lath installed over attachment flange of screeds.

D. Control Joints:
   1. Install control joints where indicated on Drawings and so plaster areas do not exceed 120 square feet, and with area sides having a maximum one to two and a half (1:2-1/2) ratio, unless otherwise approved by Architect.
   2. Coordinate joint placement with other related work. Where joints meet frames at openings, align with outside corners.

E. Plastering:
   1. Apply plaster in accordance with ASTM C926.
2. Apply first, “scratch” coat to nominal thickness of 3/8 inch, scored horizontally for mechanical key.

3. Cure scratch coat in accordance with ASTM C926, utilizing method approved by Architect.

3. Apply second, “brown” coat to nominal thickness of 3/8 inch, using magnesium darby straightedge to bring surface to a true, even plane, flush with plaster grounds. Float surface with a wood or hard rubber float to promote densification and ensure a surface with adequate “tooth” receptive to bonding of the finish coat.

4. Moist cure brown coat for minimum 48 hour period and minimum 7 days total.

5. Apply acrylic finish primer and acrylic finish in accordance with manufacturer's instructions to achieve a fine sand finish texture at a nominal thickness of 1/8 inch.

3.3 ERECTION TOLERANCES

A. Maximum Variation from Flat Surface: 1/4 inch in 10 feet.

3.4 ADJUSTING

A. Cut, patch, point, and repair plaster as necessary to accommodate other work and to restore cracks, dents, and imperfections.

B. Repair or replace work to eliminate blisters, buckles, crazing, check cracking, dry-outs, efflorescence, sweat-outs, and similar defects.

C. Finish cutting and patching to match undamaged plaster; patching shall not be visible in finished installation.

3.5 CLEANING

A. Promptly remove plaster from surfaces not indicated to be plastered.

B. Repair surfaces stained, marred or otherwise damaged during plastering.

END OF SECTION
PART 1 - GENERAL

1.1 SUMMARY

A. Section includes surface preparation and field application of paints, other coatings. “Paint” is defined as any coating system herein specified.

B. Related Sections:
1. Section 05 50 00 – Metal Fabrications: Shop primed items.
2. Section 08 12 14 – Standard Steel Frames: Shop primed items.
3. Section 09 21 16 - Gypsum Board Assemblies: Joint compound skim coat finish.
4. Divisions 22 through 23 - Shop primed plumbing and mechanical components.
5. Division 26 - Shop primed electrical components

1.2 REFERENCES

A. ACA American Coatings Association
1. ACA – Glossary of Terms

B. ASTM International:

C. AWI Architectural Woodwork Institute
1. AWS – Architectural Woodwork Standards

D. CARB California Air Resources Board
1. CARB – Architectural Coatings - 2007 Suggested Control Measure.

E. EPA Environmental Protection Agency
1. EPA Test Method 24.

F. Green Seal:
1. GC-03 – Environmental Criteria for Anti Corrosive Paints.
2. GS-11 – Product Specific Environmental Requirements

G. Painting and Decorating Contractors of America
   1. PDCA Standards.

H. South Coast Air Quality Management District:
   1. SCAQMD Rule 1113 – Architectural Coatings

I. Society for Protective Coatings
   1. SSPC – Steel Structures Painting Manual.

1.3 DEFINITIONS

A. Conform to ACA Glossary of Terms for interpretation of terms used in this section. Refer to ASTM D16 for terms not listed in ACA.

1.4 SUBMITTALS

A. Agreement for Mechanical and Control Design-Build Project - Submittal Procedure: Submittal procedures.

B. Product Data: Submit manufacturer’s literature and installation instructions for each material and accessory, clearly noting specified requirements.

C. Samples: Furnish sufficient samples to establish full range of colors and textures for materials exposed in the finished Work. Label samples to indicate product and location in the Work. Samples will be reviewed for appearance only. Compliance with other requirements is the responsibility of the Design Builder.
   1. Opaque Colors and Finishes: Submit samples, on hardboard, using materials accepted for Project, of each color and paint finish selected with texture to simulate actual conditions. Prepare three samples, 8-1/2 inches by 11 inches, with required number of paint coats clearly visible.

D. Manufacturer’s Installation Instructions: Submit special surface preparation procedures and substrate conditions requiring special attention.

1.5 CLOSEOUT SUBMITTALS

A. Agreement for Mechanical and Control Design-Build Project - Execution Requirements: Closeout procedures.

B. Operation and Maintenance Data: Submit data on cleaning, touch-up, and repair of painted and coated surfaces.

1.6 QUALIFICATIONS

A. Manufacturer and Applicator: Companies specializing in manufacturing and applying products specified in this section with minimum three years’ experience.
1.7 MOCKUP

A. Prepare benchmark sample areas per PDCA Standard P5 for each color and sheen for final review on actual wall surfaces where designated by Architect.
1. On at least 100 square feet of surface as directed, provide full-coat finish samples until required sheen, color and texture are obtained.
2. Duplicate painted finishes of prepared samples.
3. Simulate finished lighting conditions for review of in-place work.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Agreement for Mechanical and Control Design-Build Project - Product Requirements: Product storage and handling requirements.
B. Deliver products to site in sealed and labeled containers; inspect to verify acceptability.
C. Container Label: Include manufacturer's name, type of paint, brand name, lot number, brand code, coverage, surface preparation, drying time, cleanup requirements, color designation, and instructions for mixing and reducing.
D. Paint Materials: Store at minimum ambient temperature of 45 degrees F and maximum of 90 degrees F, in ventilated area, and as required by manufacturer's instructions.
E. Store only acceptable Project materials on Project site.

1.9 ENVIRONMENTAL REQUIREMENTS

A. Agreement for Mechanical and Control Design-Build Project - Product Requirements.
B. Do not apply materials when surface and ambient temperatures are outside temperature ranges required by paint product manufacturer.
C. Do not apply exterior coatings during rain when relative humidity is outside humidity ranges, or moisture content of surfaces exceed those required by paint product manufacturer.
D. Minimum Application Temperatures for Latex Paints: 45 degrees F for interiors; 50 degrees F for exterior; unless required otherwise by manufacturer's instructions.

1.12 SEQUENCING

A. Agreement for Mechanical and Control Design-Build Project - Summary: Project phasing and work sequence.
B. Sequence application to the following:
1. Do not apply finish coats until paintable sealant is applied.
2. Back prime wood trim before installation of trim.

1.13 WARRANTY
A. Agreement for Mechanical and Control Design-Build Project - Execution Requirements: Product warranties and product bonds.

B. Furnish five year manufacturer warranty for paints and coatings.

C. Colors of all surfaces finished under this section shall, at the end of one year, have remained free from serious fading, and variations, if any, shall be uniform. All materials shall have their original adherence at the end of one year, and there shall be no evidence of blisters, running, peeling, scaling, chalking, streaks or stains at the end of this period. Washing with alkali-free soap and water shall remove surface dirt without producing any deteriorating effects.

1.14 EXTRA MATERIALS

A. Agreement for Mechanical and Control Design-Build Project - Execution Requirements: Spare parts and maintenance products.

B. Supply 1 gallon of each color, type, and surface texture; store where directed.

C. Label each container with color, type, texture, and room locations in addition to manufacturer's label.

PART 2 - PRODUCTS

2.1 ACRYLIC PAINTS

A. Manufacturers: Furnish compliant products of one of the following or approved equal. Products used in combination shall be of a single manufacturer, and shall be compatible with each other. Acrylic Paint products of Kelly-Moore are listed below as the Basis of the Specification.

1. Benjamin Moore
2. Devoe Paint (Fuller O'Brien)
3. Dunn Edwards
4. Frazee (Comex)
5. Glidden Professional
6. Pittsburg Paints (PPG)
7. Sherwin Williams

B. Interior Acrylic Primer: Vinyl acrylic resin.

1. VOC Limit Compliance: CARB and GS-11; 50 g/L maximum.
2. Basis of Specification: “971 Acry-Plex Interior PVA Primer/Sealer”.

C. Interior/Exterior Acrylic Metal Primer: 100% acrylic resins, rust-inhibitive/anti-corrosive.

1. VOC Limit Compliance: CARB and GC-03; 250 g/L maximum.
2. Basis of Specification: “1725 Acry-Shield 100% Acrylic Metal Primer and Finish”.

05/22/2018
D. Exterior Acrylic Wood Primer: 100% acrylic resins, mildew-resistant. Formulated for cold-weather application.
   1. VOC Limit Compliance: CARB; 100 g/L maximum.
   2. Basis of Specification: “255 Acry-Shield 100% Exterior Wood Primer”.

E. Exterior Acrylic Masonry & Concrete Primer: 100% acrylic resins, alkali-resistant. Formulated for cold-weather application.
   1. VOC Limit Compliance: CARB; 100 g/L maximum.
   2. Basis of Specification: “247 Acry-Shield 100% Exterior Masonry Primer”.

F. Interior Acrylic Finish: 100% acrylic resins, gloss level as specified and indicated on drawings.
   1. VOC Limit Compliance: CARB and GS-11; 100 g/L maximum for non-flats, exclusive of colorants.
   2. Solids Content by Volume: 34 percent minimum (+/- 2%).
   3. Basis of Specification: “Acry-Plex 100% Acrylic Interior Enamel”.
   4. Alternate at Overhead Structure: Design Builder may substitute Acrylic Dryfall type finish on overhead metal surfaces to be painted flat black, including ducts and conduit. Primer may be omitted if rust or corrosion is not present.
      a. VOC Limit Compliance: CARB and GS-11; 50 g/L maximum.
      b. Solids Content by Volume: 29 percent minimum (+/- 2%).

G. Exterior Acrylic Finish: 100% acrylic resins, mildew resistant, gloss level as specified and indicated on drawings. Formulated for low temperature application.
   1. VOC Limit Compliance: CARB; 100 g/L maximum for non-flats, exclusive of colorants.
   2. Solids Content by Volume: 35 percent minimum (+/- 2%).
   3. Basis of Specification: “Acry-Shield 100% Acrylic Exterior Enamel”.

2.2 CLEAR COATINGS

   1. VOC Limit Compliance: CARB and SCAQMD; 275 g/L maximum.
   2. Solids Content by Volume: 25 percent minimum.
   3. Manufacturer and Product: Cabot’s “Water-Borne Polyurethane No. 8082” or approved equal.

2.3 COMPONENTS

A. Paints and Coatings: Ready mixed, except field catalyzed coatings. Prepare coatings:
1. To soft paste consistency, capable of being readily and uniformly dispersed to homogeneous coating.

2. For good flow and brushing properties.

3. Capable of drying or curing free of streaks or sags.

B. Accessory Materials: Linseed oil, shellac, turpentine, paint thinners and other materials not specifically indicated but required to achieve finishes specified; commercial quality.

PART 3 - EXECUTION

3.1 GENERAL

A. Manufacturer's Instructions: Prepare substrates, apply primers and apply the work, including components and accessories in accordance with the manufacturer's instructions, except where more stringent requirements are shown or specified. Examine the areas to receive the Work and remedy detrimental conditions.

B. Prepare and finish surfaces as specified and as scheduled at end of the Section, and as shown. Unless otherwise shown or specified, all exposed paintable type surfaces - except where specified with factory finish in their respective sections - shall receive suitable paint finish, whether or not specifically scheduled.

1. Paintable surfaces include temporary barriers exposed to public, visitors and staff during construction.

C. Surfaces Not to be Painted:

1. Manufactured products with factory finish, fabric and glass components, as specified in various Sections.

2. Prefinished wall, ceiling, and floor coverings.

3. Painting specified elsewhere and included in respective Sections, including but not necessarily limited to, shop priming and high performance coatings.


5. Surfaces concealed in walls and above solid ceilings except as specifically indicated otherwise.

6. Ducts, piping, conduit, and equipment concealed in walls and ceilings, unless specifically indicated otherwise.

3.2 EXAMINATION

A. Agreement for Mechanical and Control Design-Build Project – Administrative Requirements: Coordination and project conditions.

B. Verify surfaces and substrate conditions are ready to receive Work as instructed by product manufacturer.
C. Examine surfaces scheduled to be finished prior to commencement of work. Report conditions capable of affecting proper application.
   1. Verify smoothness of gypsum board finished surfaces for projection surface coating suitable for prime coat application.

D. Test shop applied primer for compatibility with subsequent cover materials.

E. Measure moisture content of surfaces using electronic moisture meter. Do not apply finishes unless moisture content of surfaces are below the following maximums:
   1. Plaster and Gypsum Wallboard: 12 percent.
   2. Masonry, Concrete, and Concrete Unit Masonry: 12 percent.
   3. Wood: 15 percent, measured in accordance with ASTM D4442.

3.3 PREPARATION

A. Surface Appurtenances: Remove electrical plates, hardware, light fixture trim, escutcheons, and fittings prior to preparing surfaces or finishing.

B. Surfaces: Correct defects and clean surfaces capable of affecting work of this section. Remove or repair existing coatings exhibiting surface defects.

C. Impervious Surfaces: Remove mildew by scrubbing with solution of tetra-sodium, tri-sodium phosphate and bleach. Rinse with clean water and allow surface to dry.

D. Aluminum Surfaces Scheduled for Paint Finish: Remove surface contamination by steam or high pressure water. Remove oxidation with acid etch and solvent washing. Apply etching primer immediately following cleaning.

E. Insulated Coverings: Remove dirt, grease, and oil from canvas and cotton.

F. Copper Surfaces Scheduled for Paint Finish: Remove contamination by steam, high pressure water, or solvent washing. Apply vinyl etch primer immediately following cleaning.


H. Galvanized Surfaces: Remove surface contamination and oils and wash with solvent. Apply coat of etching primer.

I. Concrete and Unit Masonry Surfaces Scheduled to Receive Paint Finish: Remove dirt, loose mortar, scale, salt or alkali powder, and other foreign matter. Remove oil and grease with solution of tri-sodium phosphate; rinse well and allow to dry. Remove stains caused by weathering of corroding metals with solution of sodium metasilicate after thoroughly wetting with water. Allow to dry.

J. Plaster Surfaces: Fill hairline cracks, small holes, and imperfections with latex patching plaster. Make smooth and flush with adjacent surfaces. Wash and neutralize high alkali surfaces.
K. Uncoated Steel and Iron Surfaces: Refer also to Division 5. Remove grease, mill scale, weld splatter, dirt, and rust. Where heavy coatings of scale are evident, remove by wire brushing or sandblasting; clean by washing with solvent. Apply treatment of phosphoric acid solution, ensuring weld joints, bolts, and nuts are similarly cleaned. Spot prime paint after repairs.

L. Shop Primed Steel Surfaces: Refer also to Division 5. Sand and scrape to remove loose primer and rust. Remove any loose mill scale or mill scale flaking. Feather edges to make touch-up patches inconspicuous. Clean surfaces with a product compatible with the primer and the finish coating system. Re-prime shop primed items in accord with the specified coating system.

M. Interior Wood Items Scheduled to Receive Paint Finish: Refer also to Division 6. Wipe off dust and grit prior to priming. Seal knots, pitch streaks, and sappy sections with sealer. Fill nail holes and cracks after primer has dried; sand between coats.

O. Interior Wood Items Scheduled to Receive Transparent Finish: Refer also to Division 6. Wipe off dust and grit prior to sealing, seal knots, pitch streaks, and sappy sections with sealer. Fill nail holes and cracks after sealer has dried; sand lightly between coats.

P. Exterior Wood Scheduled to Receive Paint Finish: Refer also to Division 6. Remove dust, grit, and foreign matter. Seal knots, pitch streaks, and sappy sections. Fill nail holes with tinted exterior paintable caulking compound after prime coat has been applied.

Q. Exterior Wood Scheduled to Receive Transparent Finish: Refer also to Division 6. Remove dust, grit, and foreign matter; seal knots, pitch streaks, and sappy sections with sealer. Fill nail holes with tinted exterior caulking compound after sealer has been applied.

R. Metal Doors Scheduled for Paint Finish: Refer also to Division 8. Prime metal door top and bottom edge surfaces.

3.4 EXISTING WORK

A. Extend existing paint and coatings installations using materials and methods compatible with existing installations and as specified.

3.5 REFINISHING

A. Existing work to be refinished shall include the following:
   1. Existing painted surfaces of rooms, areas and spaces in which alterations occur under this contract.
   2. Areas and spaces inside Project area noted on the Drawings to be refinished.

B. Except as otherwise noted or specified on the Drawings, rooms, spaces and areas shall be refinished as follows:
   1. Patched and damaged surfaces of walls shall receive prime, body and finish coats.
   2. Patched and damaged surfaces of ceilings, except prefabricated acoustical unit ceilings, shall receive prime and finish coats.
   3. Undisturbed surfaces of patched and damaged walls and ceilings, except prefabricated acoustical unit ceilings, shall receive body and finish coats.
4. Paint refinished walls and ceilings to the nearest natural break (i.e., corner, reveal or frame).

5. Painted windows (interior surfaces only), doors, frames, ceilings and all other previously painted items and trim shall receive body and finish coats.

C. Color and texture of paint, and color and texture of stain and varnish for clear finishes on wood shall match existing, unless otherwise directed.

D. Workmanship: Existing work to be refinished shall have surfaces prepared and made smooth before refinishing.
   1. Surfaces shall be clean and dry before refinishing.
   2. Abraded, peeled and bare spots shall be touched up before painting or refinishing.

3.6 APPLICATION

A. Do not apply finishes to surfaces that are not dry. Allow applied coats to dry before next coat is applied.

B. Apply each coat to uniform appearance. Apply each coat of paint slightly darker than preceding coat unless specified otherwise.

C. Sand wood and metal surfaces lightly between coats to achieve required finish.

D. Vacuum clean surfaces of loose particles. Use tack cloth to remove dust and particles just prior to applying next coat.

E. Prime concealed surfaces of interior wood surfaces scheduled to receive stain or varnish finish with gloss varnish reduced 25 percent with thinner.

F. Finishing Mechanical and Electrical Equipment:
   1. Refer to Divisions 21 through 26 for schedule of color coding and identification banding of equipment, duct work, piping, and conduit.
   2. Paint shop primed equipment. Paint shop finished items occurring at interior areas.
   3. Remove unfinished louvers, grilles, covers, and access panels on mechanical and electrical components and paint separately.
   4. Prime and paint insulated and exposed pipes, conduit, boxes, insulated and exposed ducts, hangers, brackets, collars and supports except where items are shop finished.
   5. Paint interior surfaces of air ducts visible through grilles and louvers with one coat of flat black paint to visible surfaces. Paint dampers exposed behind louvers, grilles, and convectors and baseboard cabinets to match face panels.
   6. Paint exposed conduit and electrical equipment occurring in finished areas.
   7. Paint both sides and edges of plywood backboards for electrical and telephone equipment before installing equipment.
8. Color code equipment, piping, conduit, and exposed duct work in accordance with requirements indicated and matching existing. Color band and identify with flow arrows, names, and numbering.

9. Reinstall electrical cover plates, hardware, light fixture trim, escutcheons, and fittings removed prior to finishing.

3.7 FIELD QUALITY CONTROL

A. Agreement for Mechanical and Control Design-Build Project - Execution Requirements: Testing, adjusting, and balancing.

3.8 CLEANING

A. Agreement for Mechanical and Control Design-Build Project - Execution Requirements: Final cleaning.

B. Collect waste material which may constitute fire hazard, place in closed metal containers, and remove daily from site.

3.9 SCHEDULE - GENERAL REQUIREMENTS

A. General: Major material categories only are scheduled, but all miscellaneous items and areas within a room or space shall be treated with a suitable system, unless otherwise shown or specified. This specification shall serve as a guide and is meant to establish procedure, quality and minimum number of coats.

B. Coating Thickness: Acrylic primer and paint shall be applied to the manufacturer recommended dry film, per coat thickness and in no case less than 1.4 mils. Other products shall have a minimum dry mil thickness as recommended by manufacturer, unless mil thickness is specified. Mil thicknesses are minimums, not averages.

C. Number of Coats: Where number of coats is specified, it is only as a minimum requirement. Apply additional coats, at no additional cost to Owner, if necessary to completely hide base material, produce uniform color, and provide satisfactory finish result.

3.10 SCHEDULE - EXTERIOR SURFACES

A. Steel – Unprimed and Galvanized:
   1. One coat of Interior/Exterior Acrylic Metal Primer.
   2. Two coats Exterior Acrylic Finish, semi-gloss unless otherwise noted.

B. Steel - Primed:
   1. Touch-up with Interior/Exterior Acrylic Metal Primer.
   2. Two coats Exterior Acrylic Finish, semi-gloss unless otherwise noted.

C. Wood – Unprimed (Indicated on Drawings for Opaque Finish):
   1. One coat Exterior Acrylic Wood Primer.
2. Two coats Exterior Acrylic Finish, semi-gloss unless otherwise noted.

D. Concrete and Masonry (Indicated on Drawings for Opaque Finish):
   1. One coat Exterior Acrylic Masonry & Concrete Primer.
   2. Two coats Exterior Acrylic Finish, semi-gloss unless otherwise noted.

3.11 SCHEDULE - INTERIOR SURFACES

A. Steel – Unprimed and Galvanized
   1. One coat of Interior/Exterior Acrylic Metal Primer.
   2. Two coats Interior Acrylic Finish, semi-gloss unless otherwise noted.

B. Steel - Primed:
   1. Touch-up with Interior/Exterior Acrylic Metal Primer.
   2. Two coats Interior Acrylic Finish, semi-gloss unless otherwise noted.

C. Gypsum Board:
   1. One coat of Interior Acrylic Primer.
   2. Two coats Interior Acrylic Finish, eggshell unless otherwise indicated.

D. Shop-Primed Hollow Metal Doors and Frames:
   1. Sand smooth and fill dents with automotive type filler.
   2. Two coats Interior Acrylic Finish, semi-gloss.

E. Wood – Opaque Finish:
   1. One coat of Interior Acrylic Primer.
   2. Two coats Interior Acrylic Finish, eggshell unless otherwise indicated.

F. Wood – Clear Finish
   1. Two coats of Interior Clear Wood Finish.
   2. Minimum dry film thickness: Not less than manufacturer’s recommended spreading rate.

3.12 SCHEDULE - COLORS

A. Architect reserves the right to select and vary colors on surfaces throughout the Work. Refer to requirements for samples and for mock-ups/field samples.

B. Colors: Refer to colors and locations on Drawings. Match the listed manufacturer’s standard colors:

END OF SECTION
SECTION 22 05 00
COMMON WORK RESULTS FOR PLUMBING

PART 1 - GENERAL

1.01 SUMMARY

A. Work included: Materials, equipment, fabrication, installation, starting, testing and commissioning in conformance with applicable codes and authorities having jurisdiction for Plumbing Work covered by all sections within this Division.

B. This Section applies to all sections included in Division 22 and those Sections in Division 23 that refer to this Section.
   1. Section 22 10 00 – Plumbing Piping
   2. Section 22 20 00 – Plumbing Specialties
   3. Section 23 05 00 – Common Work Results for Mechanical
   4. Section 23 08 00 – Commissioning of HVAC and Plumbing
   5. Section 23 05 29 – Hangers and Supports
   6. Section 23 05 48 – Mechanical Sound Vibration and Seismic Control
   7. Section 23 05 53 – Mechanical Identification

C. Related Sections:
   1. Agreement for Mechanical and Control Design-Build Project – General Requirements
   2. Division 23 – HVAC
   3. Division 26 – Electrical

D. Provide materials and system modifications as indicated on the Drawings.
   1. After modifications, systems shall be complete and fully operable unless indicated otherwise.
   2. Interpret the word "provide" to mean "furnish, deliver, and install ready for use".

1.02 CODES AND STANDARDS

A. Comply with applicable codes listed in Section 23 05 00, and as follows.
B. ADAAG – Americans with Disability Act Accessibility Guidelines
C. ANSI – American National Standards Institute
D. ARI – Air Condition and Refrigeration Institute
E. ASHRAE – American Society of Heating, Refrigeration, and Air Conditioning Engineers
F. ASME – American Society of Mechanical Engineers
G. ASSE – American Society of Sanitary Engineers
H. ASTM – American Society for Testing and Materials
I. AWWA – American Water Works Association
J. CGA – Canadian Gas Association
K. CSA – Canadian Standards Association
L. FM – Factory Mutual Global
M. IAPMO – International Association of Plumbing and Mechanical Officials
N. NEMA – National Electrical Manufacturers Association
O. NFPA – National Fire Protection Association
P. PDI – Plumbing Drainage Institute
Q. SDWA – Federal Safe Drinking Water Act
R. UL – Underwriters Laboratories, Inc.

1.03 SUBMITTALS

A. Submit Shop Drawings, Design Calculations, Coordination Drawings, Product Data, and Certifications as specified in Agreement for Mechanical and Control Design-Build Project and as follows.

B. Refer to Division 23 Sections for specified submittals as appropriate.

1.04 ELECTRICAL REQUIREMENTS

A. Electrical Work in this Division shall conform to requirements of Electrical Division 26.

B. Except for disconnects factory mounted on mechanical equipment or in combination starters, motor disconnects are in other Sections of these Specifications.
C. Except for factory wiring, provide raceways, relays, transformers, switches, etc. required for Work of this Section.

D. Provide controls, controllers, control wiring, EMS panels, raceways, relays, transformers, switches, etc. required for Work of this Section.

E. Factory wired assemblies and panels shall be pre-wired to numbered terminal strips for connection to field wiring.

F. Provide integral disconnect switch for each control circuit connection to pre-wired assemblies and control panels.

G. Provide approved wiring diagrams to electrical subcontractor for power wiring to be connected under Electrical Division.

PART 2 - PRODUCTS

2.01 GENERAL

A. See Section 230500 common Work Results for Mechanical, and as follows.

2.02 PIPING SUPPORTS AND ANCHORS

A. As specified in Division 23.

2.03 SLEEVES

A. Fire-Rated Barrier Penetrations:

1. Firestop assemblies shall be Hilti, 3M, SpecSeal, or equal.

2. In compliance with California Building Code, Sections 712.3 for penetrations through rated wall assemblies; Section 712.4 for penetrations through fire rated floor/ceiling and roof/ceiling.

3. Assemblies shall be listed in latest edition of UL “Fire Resistance Directory” for Through- Penetration of Firestop Devices. Assemblies shall suit the type of wall or floor construction, and type of piping material for the through penetration condition.

4. Through Interior Walls, Floors, and Ceilings:

a. For sizes up to 6" diameter: Adjus-to-Crete, KC Scott AMI, or equal, 24-gauge hot-dipped galvanized sheet metal with lock seam joints or ½” inch overlap sleeves.

5. Through Exterior Above-Grade Roofs:

a. Hot dipped galvanized Schedule 40 pipe sleeve with flashing collar.
b. Cast iron sleeve with caulking recess, anchor lugs, flashing clamp device, and pressure ring with brass bolts.

2.04 ACCESS PANELS

A. As required for service and maintenance access.

B. Provide rated assembly for rated wall installations.

2.05 VIBRATION AND SEISMIC CONTROLS

A. As specified in Division 23, same criteria as HVAC piping and equipment to be applicable to plumbing piping and equipment.

PART 3 - EXECUTION

3.01 GENERAL

A. As specified in Section 230500 Common Work Results for Mechanical, and as follows.

3.02 SLEEVES

A. General:

1. Locations of openings:
   a. Locate all chases, shafts, and openings required for the installation of the plumbing Work.
   b. Do any additional cutting, and boring, required due to improperly located or omitted openings without cost to the Owner.

2. Locate all pipe sleeves and inserts required for the installation of the plumbing Work.
   a. Set pipe sleeves parallel to the pipes that pass through them.
   b. Secure sleeves to concrete forms to prevent displacement during placing of concrete.

3. Provide sleeves of adequate diameter for pipes passing through concrete walls, floors, ceilings, etc., to allow proper passage of insulation where required and permit movement of piping due to expansion and contraction.

4. Cutting:
   a. Do any cutting of the structure under direction of the Architect and complying with pertinent provisions of Agreement for Mechanical and Control Design-Build Project.
b. Holes are prohibited in any structural member without written approval of the Architect.

c. See Structural Drawings.

5. Smooth up rough edges around sleeve with plaster.

6. Provide split type steel plates on all exposed pipes passing through floors, walls, partitions, plaster furring, etc. In unfinished rooms, provide prime coated plates. In finished rooms provide nickel plated plates.

B. Provide sleeves in locations where pipes or conduits pass through floors, walls, partitions, and/or roofs.

1. Sleeves must be a minimum internal diameter 1” larger than outside diameter of pipe and insulation except for sleeves connecting buildings, which shall be a minimum of 1½” larger.

C. Provide sleeves in locations where pipes or conduits pass through fire-rated walls, fire-rated floors.

1. Seal all penetrations through all fire rated construction (walls, enclosures, ceilings, floors) with Underwriter's Laboratories listed assemblies and Building Code approved materials, providing equivalent protection and rating of the construction being penetrated. Installation shall be per manufacturer’s and UL requirements.

2. Bare pipe:

a. All steel pipe or copper tubing penetrating fire walls or decks shall be encircled by sheet metal sleeves sized for maximum one inch annular spacing between pipe and sleeve.

b. Spacing shall be packed on each end with UL rated ceramic fiber strip insulation.

3. Insulated pipe:

a. Same as for bare pipe, but with the addition of a 360 degree cylinder of waterproofed calcium silicate insulation encasing the pipe and covered with galvanized sheet metal shielding, all sized to extend to a minimum of one inch beyond wall or deck.

4. Sleeve and packing shall have the same fire rating as the partition construction in which they are installed; substitutions shall have passed the ASTM E119 test, in accordance with UBC 43-1 for pipe penetrations.

5. Calking such as 3-M fire barrier calking, CP-25, or Metacaulk, with 3-hour rating, shall be applied additionally for 4-hour wall penetrations.
D. Provide sleeves in locations where pipes or conduits pass through light-proof walls, sound-proof walls, floors, and/or partitions.

1. Pack space between the sleeve and pipe/conduit or insulation with non-shrink grout, ceramic fiber, or other approved sealant materials.

2. Approved pre-fabricated assemblies including Pipe Shields are acceptable.

E. Provide sleeves in locations where pipe or conduits pass through concrete walls, slabs, and exterior walls. See details on Contract Drawings for information.

F. Provide sleeves in locations where pipe or conduits pass through roof construction. Install in strict accordance with project roofing specifications.

G. Provide sleeves in locations where pipe or conduits pass through waterproofing membranes. Install in strict accordance with membrane waterproofing manufacturer’s recommendations.

3.03 ACCESS PANELS

A. Provide access panels for valves, trap primers, funnel drains, and water hammer arresters behind inaccessible ceiling and walls.

B. Coordinate with Architect for exact locations of access panels.

3.04 ESCUTCHEON PLATES

A. Escutcheon plates shall be securely held in position allowing enough clearance to care for expansion and shall have sufficient size to cover the opening around the pipe.

3.05 INSULATION

A. As specified in Division 23 and as follows.

B. Insulate all domestic hot water piping, including run-outs to fixtures.

C. Insulate all rainwater leaders in plenum with ½” thick flexible elastomeric type insulation.

D. Insulate all piping embedded in concrete with 1” thick flexible elastomeric type insulation.

3.06 COMPLETION

A. The Work herein will not be reviewed for final acceptance until operations and maintenance data, manufacturer’s literature, valve directories, piping identification code directory, and nameplates specified herein have been approved and properly posted in the building, and final cleaning has been completed.

B. When the installation is complete and adjustments specified herein have been made, operate the systems for a period of one week, during which time demonstrate to the Architect that systems are completed and operating in conformance with these Specifications.
<table>
<thead>
<tr>
<th>Project</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-1129 PAC Boiler Replacement</td>
<td>D-1044 Campus-Wide EMS Upgrades</td>
</tr>
<tr>
<td>C-1130 PAC Chiller Replacement</td>
<td>D-4017 Mechanical Equipment Retrofit</td>
</tr>
<tr>
<td>C-1131 AT Packaged Unit Replacement</td>
<td>P-4022 AHU Replacement</td>
</tr>
</tbody>
</table>

END OF SECTION
PART 1 - GENERAL

1.01 WORK INCLUDED

A. The work includes, but is not necessarily limited to, the furnishing and installing of all plumbing work, as shown and noted on the Drawings and specified herein. It is not necessarily all inclusive. At completion of work, all systems shall be continuous, operational, and functioning in the proper manner. This section shall be responsible for determining all items and quantities required.

1. Domestic cold water piping system, including connections mechanical equipment.

2. Natural gas piping system, including new gas piping extensions, gas pressure regulators, and connection to HVAC equipment.

3. Coordination between this Section and architectural and structural.

4. Pipe hanger and support devices, and seismic bracing of piping and equipment.

5. Pressure testing of installed piping systems.

6. Cleaning and flushing of all piping systems.

7. Furnish and install all metal fabrications required for piping and equipment supports.

8. All rigging, hoisting, transportation, and associated work necessary for placement of all equipment in the final location shown.

9. Pay all necessary permit fees.

B. Related Work Specified Elsewhere

1. Agreement for Mechanical and Control Design-Build Project – General Requirements

2. Division 03 – Concrete

3. Section 220500 – Common Work Results for Plumbing

4. Division 23 – HVAC

5. Division 26 – Electrical
1.02 CODES AND STANDARDS
A. As specified in Section 230500.

1.03 GENERAL REQUIREMENTS
A. As specified in Section 230500 and as follows.
B. All materials, including but not limited to pipes, fittings, valves, etc., installed for potable water system for human consumption shall be lead-free, in accordance with Safe Drinking Water Act, AB1953, and NSF 61G.
C. Solution used for system disinfection and sterilization shall be discharged in an approved manner per local ordinances and EH&S requirements. Design Builder shall be responsible for managing, storing, and removing discharged solution to an approved hazardous waste management station off-site.

1.04 ELECTRICAL REQUIREMENTS
A. As specified in Section 220500.

1.05 SCHEDULING AND SEQUENCING
A. As specified in Section 230500.

1.06 SUBMITTALS
A. As specified in Section 230500.

1.07 MATERIALS
A. As specified in Section 230500.

1.08 OPERATION AND MAINTENANCE DATA MANUALS
A. As specified in Section 230500.

1.09 DELIVERY, STORAGE, AND HANDLING
A. As specified in Section 230500 and as follows.
B. Protect all piping from entrance of foreign materials with temporary caps, or covering. Complete all sections of piping, or cap at end of shift. Maintain all temporary piping end caps until next connection of piping or completion of rough-in and connect.

1.10 TESTING AND SYSTEM ACCEPTANCE
A. As specified in Section 230500.
1.11 WARRANTY
   A. As specified in Section 230500.

1.12 QUALITY ASSURANCE
   A. As specified in Section 230500 and as follows.
   B. Installation of flange gaskets shall be in strict conformance to the gasket manufacturer's recommendations including bolt pattern and torque requirements.
   C. All valves shall have ratings stamped on the valve bodies.
   D. All valves shall be full-port, unless otherwise herein specified.
   E. All pipes shall be marked with the names or trademarks of the manufacturers and type of pipes.
   F. Cleaning, passivation, and/or disinfection of systems shall be performed by company that is qualified and regularly engaged in sterilization work.

PART 2 - PRODUCTS

2.01 MATERIALS OF CONSTRUCTION
   A. As specified in Section 230500.

2.02 PRESSURE PIPING AND FITTINGS
   A. Copper tubing for water service: Hard drawn deoxidized water service tubing conforming to ASTM B88, Type "L" and Type "K" as specified herein.
   C. Flanges for Copper Tubing: ASME B16.24 cast copper alloy.
   D. Soft Copper Tubing: Soft Annealed ASTM B88, Type "K" tubing, and ANSI B16.22 fitting.
   E. Threaded to Solder Adaptors: As specified for solder type fittings.
   F. Solder: Harris, Engelhard, or equal, ASTM B32 lead-free solder for all water piping.
   G. Harris, Engelhard, or approved equal, BCuP filler material for brazing of copper fitting joints.

2.03 VALVES
   A. Domestic and Emergency Water Piping Systems: In compliance with Section 1417 of SDWA, and NSF-61G Standards.
1. Ball Valves, 2” Size and Under: Nibco T-685-80-LF, Milwaukee UPBA-475B, Red and White, Apollo, Kitz, or equal, lead-free, threaded ends, 600 PSI WOG, 150 PSI, two-piece bronze body with bronze trim and full port chrome-plated ball.

2. Butterfly Valves, 2-1/2” and larger: Watts DBF-03, Nibco LD-2020-3-LF, Danfoss Flomatic, or equal, lead-free, ductile iron, lug style body, with molded-in EPDM liner, stainless steel disc, extended neck, and lever-lock handle, 200 PSI.

B. Natural Gas System:

1. Sizes 1 ½” and smaller: Nibco T-FP-600, Apollo Valves 77G, Red & White Fig 5044F, UL Listed, and CSA approved, 2-piece full port brass ball valve with threaded ends, 600 PSI.

2. Sizes 2” and larger: Homestead 602, Nordstrom 115, DeZurik 425, or equal, semi-steel, lubricated plug valve with threaded ends or flanged ends.

2.04 CHECK VALVES

A. Potable Water Systems: In compliance with Section 1417 of SDWA, and NSF-61G Standards

1. For 2” size and smaller: Nibco T-413-Y-LF, Red and White Model 236, Kitz Model 822T, or equal, lead-free, Y-Pattern swing check, bronze body and bronze trim, threaded ends, Class 125, 200 PSI WOG.

2. For 2-1/2” size and above: Mueller 105MAP, Danfoss Flomatic, or equal, lead-free, spring-loaded lift disc check, globe body with cast iron construction and bronze trim, flange ends, Class 125, 200 PSI WOG, and rated at 150°F.

2.05 CIRCUIT BALANCING VALVES

A. NIBCO T-1810-LF, Bell & Gossett “Circuit-Setter”, Griswold, or equal, lead-free DZR brass bronze body, fixed orifice, two metering / test ports with integral checks and caps, position memory stop and calibrated name plate, and threaded ends.

B. Balancing valves must comply for potable water use.

2.06 PRESSURE REGULATORS

A. Natural Gas: American Meter Co. Series 1800 or Equimeter model 243, complete with aluminum body and top, cast valve head, with internal relief vent, over pressure shut-off feature, vent port connection.

1. Gas regulators located inside of building shall have vents piped to the outside.

2. Gas regulators located outside shall be installed with vent port pointing down or horizontal.
2.07 **UNIONS AND DIELECTRIC FITTINGS**

A. Unions for Steel Pipe:
   1. 2" size and smaller: Malleable iron, ground joint pattern, brass to iron seat, female threaded-end connections, 150 PSI.
   2. 2-1/2" size and larger: Standard 150 PSI flanges with gaskets and bolts.


C. Copper to Ferrous Connections: Epco, Vallet, or Ecoff dielectric pipe unions, threaded or flanged as required with gaskets rated at 250 PSIG.

2.08 **FLEXIBLE CONNECTORS**

A. Dormont, Brass Craft, or equal, CSA approved, 304 stainless steel, flexible with SAE J512 flare and compression fitting for natural gas service, 0-10 PSI rated.

B. Flexible gas connectors shall be used to connect appliances to piping system downstream of appliance shut-off valve not greater than 36” distance.

2.09 **PIPING SUPPORTS AND ANCHORS**

A. As specified in Section 230529.

2.10 **INSULATION**

A. As specified in Section 230700.

2.11 **STENCILING, IDENTIFICATION, AND COLOR CODING OF PIPES**

A. As specified in Section 230500, and as specified below.

B. MSI, Brady, Seton, or equal, conforming to ASME A13.1.

2.12 **ESCUTCHEON PLATES**

A. Split ring type, chromium-plated steel plates with brass set screw to hold escutcheon securely in place.

B. Split ring type, chromium-plated steel plates with hinge and springs.

C. Brasscraft, Dearborn Brass, or equal, shallow chrome-plated one-piece escutcheons for piping rough-ins at face of wall.
PART 3 - EXECUTION

3.01 GENERAL

A. See Section 230500 and as follows.

B. Check all piping runs before hand with all other trades. Run piping to maintain proper clearance for maintenance and to clear opening in exposed areas. Run piping in strict coordination with existing mechanical piping, ducts and equipment, structural and architectural conditions. Piping shall be concealed in designated ceiling spaces, and wall spaces, unless otherwise noted for exposed installation. Where work of other trades prevents installation of the piping as shown on the Drawings, reroute piping at no extra cost. Verify all inverts and pitched lines before starting work.

C. Install all exposed piping parallel to or at right angles with building walls and tight to walls or ceilings wherever possible, except where otherwise shown on the Drawings. Install all piping below the bottom of beam elevations; provide sleeves as required. Install no-hub coupling bands with screws as far back as possible behind pipes.

D. Install all piping free from traps and air pockets and true to line and grade. It is important that all water, deionized water, and lab vacuum piping can be drained by gravity.

E. Where exposed pipes pass through furred walls and suspended ceiling, fit in all finished rooms and conspicuous locations with escutcheon plates. Escutcheon plates must be securely held in position allowing enough clearance to care for expansion and shall be sufficient size to cover the opening around the pipe.

F. Support all pipe from the building structure so that there is no apparent deflection in pipe runs. Piping or equipment shall be immobile and shall not be supported or hung by wire, rope, plumber's tape or blocking of any kind. Do not support piping from ducts, other pipes, conduit, or any materials except building structure.

G. Piping support spacing shall comply with CPC Tables 3-2 and 12-3, and as noted in table below. Bracing and seismic restraints shall be per CBC and as specified in Section 230529. Hanger rods and spacing shall be as follows, at minimum:

<table>
<thead>
<tr>
<th>Pipe Size (Inches)</th>
<th>Min. Rod Size (Inches)</th>
<th>Spacing (Feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Copper Tubing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hubless Cast</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Iron Pipe</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Steel Pipe</td>
</tr>
<tr>
<td>1 &amp; Smaller</td>
<td>3/8</td>
<td>5</td>
</tr>
<tr>
<td>1-1/4</td>
<td>3/8</td>
<td>6</td>
</tr>
<tr>
<td>1-1/2 to 2</td>
<td>3/8</td>
<td>6</td>
</tr>
<tr>
<td>2-1/2 to 3</td>
<td>1/2</td>
<td>10</td>
</tr>
</tbody>
</table>

*Each branch of piping over 3 feet long shall have a separate hanger.

** Every other joint, unless over 4 feet, then support each joint.

H. Insulate for dissimilar metal where copper tubing comes in contact with ferrous material with double wrapped heavy vinyl tape.
I. No valve and no piece of equipment or trim shall support the weight of any pipe. Support piping independently at pumps and the like so that its weight will not be supported by the equipment.

J. Install all valves, vents, traps, cleanouts and other trim in accessible locations.

K. Make all changes in direction with fittings, unless otherwise herein specified.

L. Wherever changes in sizes of piping occur, make such changes with reduced fittings, as the use of face bushings will not in general be permitted. Install eccentric reducing fittings where necessary to provide free drainage of lines.

M. Unless otherwise noted, install water supply and return piping with straight side of eccentric fittings at top of pipe.

N. Provide sufficient swing joints, seismic joints, expansion loops and devices necessary for a flexible piping system.

O. Install a union on downstream side of threaded-end valves, cocks, equipment and at other points where required for disassembly or where shown.

P. Furnish and install insulating unions or insulating flanges as hereinbefore specified at all connections of ferrous and nonferrous piping. Insulating devices shall completely isolate metal-to-metal contacts between dissimilar metals.

Q. Unless otherwise noted, provide threaded joints on steel piping 2 inches and smaller, and welded joints on black steel piping 2-1/2 inches and larger.

R. Close all openings in pipes with appropriate caps, plugs, or covers during progress of the Work to preclude introduction of undesirable materials.

S. At completion of work, no piping exhibiting rust will be accepted.

3.02 COLD WATER PIPING

A. Type "L" copper tubing with wrought copper solder-joint fittings.

1. For 2" size and smaller: Lead-free soldered joints.

2. For 2-1/2" size and larger: Silver-brazed joints.

B. Provide dielectric unions for all connections between ferrous and copper piping.

3.03 COMPRESSED AIR, CARBON DIOXIDE, AND NITROGEN PIPING

A. Type "L" copper piping and wrought copper fitting. Joints are silver-brazed.

3.04 INSULATION

A. As specified in Section 230519.
3.05 SLEEVES
   A. As specified in Section 220500.

3.06 ESCUTCHEON PLATES
   A. As specified in Section 220500.

3.07 LABELING AND IDENTIFICATION
   A. As specified in Section 220500.

3.08 VALVE TAGS
   A. As specified in Section 220500.

3.09 CLEANING
   A. As specified in Section 220500 and as follows.
   B. All field cut pipe ends shall be squared and reamed to full bore of piping to remove all burrs and chips. Follow the installation instruction for each fitting manufacturer when assemble joints.
   C. Thoroughly clean, flush, and drain all drainage and water piping systems of any nature of piping contaminants such as cuttings, filings, lubrication, rust, scale, grease, solder, flux, debris with clean water prior to testing.

3.10 VALVE INSTALLATION
   A. Valve handles of piping in concealed ceiling spaces shall be installed in horizontal position such that handles clear ceiling tiles. No valve handles shall be installed below the horizontal axis of the valve.
   B. All drain valves shall be located above accessible areas.

3.11 ADJUSTMENT
   A. Check valve positions to ensure all on-off valves are either completely open or completely closed.
   B. Lock all balancing valves in position after system balancing is complete.

3.12 TESTING
   A. Before conducting tests, valve-off or disconnect any equipment and apparatus which may be damaged by the test pressures higher than normal working pressures.
   B. All testing shall be witnessed and approved by the Owner’s Representative and local authority.
C. Cold Water: Test and prove tight hydrostatically at a pressure of 150 PSI.

D. Natural Gas:

1. Low pressure gas piping shall be tested with dry, oil-free, compressed air at 15 PSI, in accordance with California Plumbing Code, and NFPA 54. Medium pressure gas piping shall be tested with clean dry oil-free compressed air at 60 PSI. See paragraph 3.05 above for purging procedure.

2. After gas piping system is completed, purge piping system with clean-dry, oil-free compressed air or nitrogen gas. Once gas piping system is successfully pressure tested, purge test media from piping system to atmosphere with nitrogen gas. Slowly displace test media gas with natural gas by venting high end to atmosphere. Provide natural gas detector to detect if natural gas piping is completely filled.

END OF SECTION
1.01 SECTION INCLUDES

A. The scope of work covered by these specifications includes the complete design and installation of all mechanical HVAC and controls renovation and upgrades, including all required work by other disciplines to support the upgrade work for this project. The scope includes furnishing all drawings, specifications, calculations, design, equipment, material and labor necessary for complete and operable systems, including General Conditions and Agreement for Mechanical and Controls Design-Build Project.

B. This project is funded by California Measure E and Proposition 39 bonds. The projects shall be identified as follows:

<table>
<thead>
<tr>
<th>Project No.</th>
<th>Description</th>
<th>Funding</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-1129</td>
<td>Contra Costa County College PAC-Boiler Replacement</td>
<td>Proposition 39</td>
</tr>
<tr>
<td>C-1130</td>
<td>Contra Costa County College PAC-Chiller Replacement</td>
<td>Proposition 39</td>
</tr>
<tr>
<td>C-1131</td>
<td>Contra Costa County College AT Packaged Unit Replacement</td>
<td>SM State Funds</td>
</tr>
<tr>
<td>D-1044</td>
<td>Diablo Valley College Campus wide EMS upgrades</td>
<td>Proposition 39 and Measure E</td>
</tr>
<tr>
<td>D-4017</td>
<td>Diablo Valley College Mechanical Equipment Retrofit</td>
<td>Measure E</td>
</tr>
<tr>
<td>P-4022</td>
<td>District Building AHU Replacement</td>
<td>Measure E</td>
</tr>
</tbody>
</table>

See Drawings for a complete detailed description of work.

See Instruction to Builders for additional Bid requirements.

C. This project is a design-build project. This Basis of Design Drawings and the accompanying specifications are meant to portray the design intent and quality of materials. Not all systems are sized or documented. It will be the responsibility of each trade to take the design intent, complete all calculations for loads, equipment sizing, duct sizing, and pipe sizing, and to create complete and coordinated construction documents and permitting documents. The Design Builder will be the Engineer of Record for the project. The Design Builder will be expected to attend all required coordination and design meetings as stipulated by the Architect and Owner. All Design Builders will be required to coordinate routing of all their respective utilities and create composite coordinated construction documents to be sent to the District for review. Quantity of drawing submissions will be stipulated by the Architect and the Project Manager. All
design and construction documentation will be completed on AutoCAD with the version as required by the Architect. All files will be made available in CAD, and PDF files to the Architect and the Owner.

D. At the end of construction provide Operations and Maintenance manual and As-built/record documents per the Agreement for Mechanical and Control Design-Build Project requirements.

1.02 RELATED SECTIONS

A. Division 23
B. Division 26

1.03 EXISTING DRAWINGS

A. The existing drawings will be provided by the District in CD ROM. These drawings are for reference only. The Design Builder shall perform field investigation of the existing condition as necessary to complete their work.

1.04 DESCRIPTION OF WORK

A. The work includes but is not necessarily limited to the following general headings:

1. Evaluation of design criteria, codes, and College requirements.

2. Participation in the design process with the District’s Representative and consultants as well as other design-team members and consultants.

3. Complete design, calculations, drawings, and specifications from all disciplines to complete this project. All (Mechanical, Electrical, Structural and Architectural) calculations, drawings, and specifications shall be performed, stamped and signed by the respective California licensed professional engineers and architects.

4. Plan check/permit process.

5. Peer review including responses to comments.

6. Shop drawings and submittals.

7. Record as-built documents.

8. Operations and maintenance manuals.

9. Equipment and systems training for District’s personnel.

10. Testing and Balancing

11. Commissioning.
12. Cutting, drilling, notching for installed systems.
13. All bases, seismic bracings, supports and hangers for installed systems.
14. Title 24 and Cal Green calculations and documentations.
15. Re-insulation of existing ductwork and piping removed by this work and due to hazardous material abatement work.
16. See subsequent sections for detailed descriptions.
17. See performance criteria documents.

1.05 DESIGN-BUILD REQUIREMENTS

A. Intent of document: It is the intent of this document to describe the requirements of a design/build contract to construct the mechanical work for the project.

B. Role of the Design Builder: The role of the Design Builder is that of an active participant of the design team for the design and construction of the project.

1. Design phase: Take the initiative at all times to ensure that there is free and open communication with other members of the design team and timely and orderly transfer of data and information relating to the mechanical work. In order to achieve this:

a. Participate in design conferences/meetings with the District and the design team at least once a week to discuss the District’s program requirements, design issues, to define design goals and to keep other members informed of current progress.

b. Outline in advance any proposed changes to the scope of the project as presently described and obtain District approval before proceeding further.

c. Anticipate the needs of other members of the design team and provide all necessary data, sketches, equipment sizes, weights, clearances, power requirements, etc., in order to enable them to incorporate these requirements in their designs.

d. Request information relating to his work from other members of the team in a timely and orderly manner, and incorporate these requirements and data in the mechanical designs.

e. Review code requirements as they relate to the mechanical systems, and discuss with the District State Fire Marshal, District EH&S, DSA, UCSF Facilities Management, and other authorities having jurisdiction, to clarify any doubtful points in order to ensure that the design meets all current codes and standards.
f. Maintain complete and orderly records of all design decisions, transfer of information, communications with other members of the design team, UCSF State Fire Marshal, UCSF EH&S, DSA, UCSF Facilities Management, and other authorities having jurisdiction, so that there is a clear record of the design process.

g. Coordinate mechanical equipment vibration isolation needs with acoustic consultant.

h. Provide seismic bracing of systems in accordance with code requirements and criteria provided by the Structural Engineer.

i. Prepare and submit California Energy Efficiency Standards and Cal Green documentations.

j. Obtain approvals from the Fire Marshal and DSA Representative.

k. Obtain other permits.

2. Construction phase:

a. Provide a complete construction/design team, adequately staffed and supported in order to prosecute the work efficiently and to ensure complete coordination of the design and construction process.

b. Provide continuous supervision of the work at the jobsite.

c. Provide all necessary design and construction support in making necessary field changes to avoid conflicts and interference with the work of other trades.

d. Participate and perform a complete commissioning on the new work. The District will retain the service of an Independent Commissioning agent to prepare the commissioning document and conduct the entire commissioning process.

1.06 DESIGN REQUIREMENTS

A. Performance Criteria Documentation

1. The systems, equipment locations, equipment sizes and capacities, points of connection, routing, coordination, etc. shown on the drawings and described in the specifications are to be considered as approximate in nature and are to be used for general guidance only. Be responsible for all aspects of the design and coordination with other trades and to prepare independent final construction documentation consisting of design drawings, shop drawings, specifications, and submittals.
B. Qualification of Designer:
   1. Contract documents and calculations shall be prepared under the direct supervision of a State of California registered engineer in charge, and shall be stamped and signed by the California Registered Engineer in charge.

C. Design Review:
   1. The design shall be subject to review by the District and the District’s Representative at any time to check compliance with the project objectives, codes, and standards.
   2. This review shall not relieve the Design Builder from full responsibility to meet all requirements of these documents and to provide a complete and satisfactory installation.

D. Design Analysis:
   1. All design analysis and load computations shall be presented for review as part of the construction documents package.
   2. Design computations shall form the basis of equipment selection. Where the capacity of the selected equipment differs from the calculated load requirement, the design analysis shall justify such difference.
   3. HVAC load analysis shall include a computerized load analysis. The program input and output shall be presented, in a form that is self explanatory, for review by the District and the District’s Representative, and shall be the basis of the equipment selection. Modifying input to insure adequate capacity shall be explained by separate annotation.
   4. Electrical design analysis and load computations shall include load and voltage drop calculations for all major equipment and panelboards. Provide complete short circuit and overcurrent device coordination study.
   5. Sizing of Electrical Equipment and Feeders: Calculated size shall comply with California Electrical Code requirements for connected loads, continuous and non-continuous loads, demand factors and voltage drop.
   6. In addition to computerized load calculations, the calculations used as basis for all system components shall be submitted for review in an acceptable format in 8-1/2” x 11” paper.

E. Drawings:
   1. Drawings shall be in AutoCAD version acceptable to the District.
   2. Drawings shall be prepared by competent draftspersons.
   3. Floor plans shall be drawn to the same scale as the architectural drawings with larger scale plans, sections, elevations, and details of selected areas where
required to show the conditions clearly and accurately. 1/8" scale for design drawings and ¼" scale for shop drawings are recommended.

4. The drawings shall show clearly all equipment, air outlets, air flow rates, equipment schedules and component schedules and all details and control diagrams necessary to define the work completely. The proposition that "in-house" Design Builder expertise should provide data and detail not shown on the drawings or specifications is not acceptable. The drawings shall be complete in themselves to the same extent that drawings for competitive bidding are generally prepared. This is necessary for the District's records.

5. Show duct and pipe riser diagrams in addition to plans and clarifying sections.

6. Drawings shall include legends, equipment schedules, California Energy Efficiency Standards compliance, floor plans, zone plans, sections, ducting, control diagrams and control sequences, details, duct riser diagrams, pipe riser diagrams, and piping diagrams.

F. Specifications:

1. Specification shall be included in the Construction Document phase. Specifications are to be in accordance with the format directed.

2. The specifications shall complement the drawings and shall describe the quality of materials and workmanship in a detailed and comprehensive manner.

3. Specifications shall be particular to this project and the use of generalized standard specifications will not be acceptable. Edit material specifications derived from manufacturer's published data to meet the specific requirements of this project.

4. Specifications included in the bid documents are minimum requirements.

5. Print specifications on 8-1/2” x 11” paper and in a format directed by the Project Engineer.

6. The specifications shall be complete and comprehensive to the same extent that specifications for competitive bidding are generally prepared, for the District’s benefit and for the permitting process.

G. Inspections:

1. Inspections: All work shall be regularly inspected and the report be made available at the job site.

H. Acceptance Verification and Testing

1. Acceptance shall be contingent on, but not limited to:

   a. Completion of the installation of all systems required under the Contract Documents.
b. Correction of deficiencies.

c. Satisfactory completion of the training required by the Contract Documents.

d. Completion of Acceptance Verification and Testing.

e. It is the Design Builder’s responsibility to plan, perform, and document acceptance verification and testing.

f. Submit the acceptance verification and testing plan and forms to the Owner, for review and approval, prior to proceeding with the work.

g. Each acceptance testing form shall individually detail acceptance testing procedures and/or observations for every component and each system. Acceptance testing forms shall include check boxes for "acceptance" and "rejection" of each test or observation. Forms shall have place for signatures of the Owner and Design Builder to certify tests and/or observations.

h. Tests and observations are required for, but not limited to:

1) Installation of equipment and systems accordance with the Contract Documents, shop drawings, regulations, etc.

2) Seismic bracing.

3) Vibration isolation.

4) Service clearances to equipment, including electrical panels and cable trays.

5) Equipment start-up.

6) Identification.

7) Cleaning.

8) Testing and Balancing.

1.07 REQUIREMENTS OF REGULATORY AGENCIES

A. Codes: Provide work in accordance with appropriate standards, codes, and recommendations, including those of the following agencies:
1. 2016 California Building Code
2. 2016 California Plumbing Code
4. 2016 California Fire Code
5. 2016 California Electrical Code
6. 2016 California Energy Efficiency Standards
7. Underwriters Laboratories (UL).
9. CALOSHA.
10. California Code of Regulations (CCR) Title 8, 9, 22, and 24.

B. Energy Codes: All equipment, systems, and insulation installed in this division shall comply with the minimum requirements of 2016 California Energy Efficiency Standards.

C. Nothing in the Contract Documents shall be construed to permit work not conforming to the applicable laws, ordinances, rules, regulations.

D. When requirements of the Contract Document exceed requirements of applicable laws, ordinances rules, regulations, the requirements of the Contract Documents shall take precedence.

1.08 PERMITS, LICENSES, AND INSPECTIONS
A. Permits: Pay for all permits required by work under this Division.
B. Inspections: All work shall be regularly inspected and certificates of approval shall be delivered to the District.

1.09 DESIGN CRITERIA
A. Design and install the Mechanical, Electrical and related Architectural and Structural work in accordance with the guidelines, and specific criteria described in this section and other sections of Division 23.
B. Generate, and coordinate mechanical criteria for the project, including requirements of code, District, and those of other trades.
C. When appropriate to facilitate the completion of the work, present proposals, cost data and recommendations on alternative equipment and methods covering various portions of the work, and assist the District and its representatives in evaluating such alternatives.
D. The design of the systems shall be subject to the overall direction and coordination of the Design Builder.

E. During the design phase, provide all necessary data, ratings, weights, clearances, and any other information required to permit other members of the design to coordinate their work fully with the mechanical work. Participate actively in all design conferences and cooperate fully in developing solutions to design problems and in exploring alternatives as necessary. Prepare sketches where required to illustrate the physical arrangement of equipment and clearances required.

F. Provide all information on required openings, equipment weights, and sizes to the structural engineers during the design phase.

G. Coordinate rooftop equipment screening requirements, equipment support on roof, duct support on roof, duct penetrations through roof, duct shaft requirements, ceiling clearances, service accesses, etc. with the Project Engineer.

H. Coordinate with the electrical Design Builder the power required for the equipment.

I. The electrical Design Builder is to provide the mechanical Design Builder with heat release information for transformers, etc.

J. Coordinate adequate power sources and division of responsibilities for installing and wiring control devices, fire/smoke dampers, etc.

K. Incorporate the noise and vibration mitigation requirements per the ASHRAE standard.

L. Provide seismic bracing of systems.

M. During the construction phase, coordinate work with that of other trades in order to ensure fully functioning and integrated assembly of all work.

N. Furnish information promptly and in such a manner as to facilitate the scheduling of the work of other trades and to avoid delay in the overall progress of the construction.

1.10 SEISMIC DESIGN CRITERIA FOR NEW WORK

A. Seismic Design Parameters:

1. Seismic Design Category – D

2. \( S_{DS} = 1.267 \)

3. Seismic Importance Factor for the building, \( I_e = 1.0 \).

4. Seismic Importance Factor for nonstructural components, \( I_p = 1.0 \)

5. \( a_p, R_p = \) in accordance with ASCE 7 Tables 13.5-1 and 13.6-1.

B. Interstory Drift – 0.01 times the story height (Importance factor already included).
1.11 SHOP DRAWINGS AND SUBMITTALS

A. Submit shop drawings and supplemental data for all materials and equipment providing at a minimum 5 copies or as directed. Submit shop drawings in AutoCAD acceptable to the District’s Representative.

B. Forward all submittals for the District review together, at one time. Individual or incomplete submittals will not be acceptable.

C. Identify each item by manufacturer, brand, trade name, number, size, rating, or whatever other data is necessary to properly identify and check materials and equipment.

D. Identify each substantial item by reference to the specification section paragraph in which the items specified or drawing and detail number.

E. Organize submittals in the same sequence as they appear in specification sections, articles or paragraphs.

F. Any mechanical, electrical, structural, or other changes required for the installation of any approved substantial equipment provided as part of the work of this division shall be made to the satisfaction of the District and District’s Representative at no increase in contract price. Approval by the District of the substituted equipment and/or dimensional drawings does not waive these requirements. Submit drawings of equipment spaces showing substituted equipment prior to installation.

G. Approval of equipment shall not be construed as authorizing any deviations from the approved contract documents unless the attention of the District and District’s Representative has been directed to the specific deviations.

H. Furnish upon request, complete installation instructions on all material and equipment to be provided part of the Work of this Division before commencing installation of same.

1.12 COORDINATION DRAWINGS

A. Individual trade Design Builders are responsible for developing CADD drawings for the purpose of coordinating all above-ceiling utilities. The coordination effort shall include, but not be limited to, plumbing, electrical conduits, electrical panels, lights, structural, door jamb studs, ceiling hangers, braces, sprinklers, and ceiling miscellaneous steel.

B. Coordination must be performed in 3-dimensional (3D) CADD drawings. See Agreement for Mechanical and Control Design-Build Project for additional requirements.

C. Meetings shall be held to coordinate the locations of utilities and resolve conflicts. Revise the ceiling coordination CADD drawings to show changes in layout. Meetings at the project site, at a minimum will be conducted once every other week, until the AutoCAD coordination drawings have been completed. The MEP and Architectural/Structural coordination team will meet as needed throughout the project as required to coordinate the work.

1. Coordinate with all other trades and District-supplied items.
2. Check routing and elevations of all ductwork, piping, conduit, raceways, etc., and equipment before fabricating.

3. Report conflicts that cannot be solved in the field to the District’s Representative.

4. Extra charges shall not be allowed due to lack of coordination prior to, or during, construction.

5. Distribute Drawings to trades that are affected.

6. In addition to plan view, indicate the exact locations and sizes of all conduits, piping, ductwork, equipment, and openings through walls. Indicate heights and clearances from structure and from other trades. Use partial sections where necessary.

7. Provide proper clearances for access to and service of all equipment and items requiring adjustment including shutoff valves, electrical equipment, etc.

8. The coordination Drawings are be reviewed and checked for completeness.
   a. The coordination drawings need not be submitted for review, but shall be available for examination to discuss coordination issues as they arise.
   b. Any review performed by the District’s Representative will only cover design intent.
   c. Responsibility for proper coordination remains with the design/build Design Builders and their engineers-of-record.

D. Be responsible for coordinating and settling differences or disputes concerning coordination, interference, or extent of work. Agreed upon decisions shall be at no additional cost to the District.

E. Prepare a Mechanical-Electrical coordination schedule to achieve completed and approved Mechanical-Electrical coordination plan prior to installation of each area in accordance with the project schedule.

1.13 RECORD DRAWINGS

A. Record Drawings: Provide a minimum of two complete sets of heating, ventilating, and air conditioning drawings as Record Drawings and Specifications, which shall be separate, clean, and reproducible for the purpose of showing a complete picture of the work as actually designed. Submit in hard copy format as well as 2 sets of CD-ROMs. See Agreement for Mechanical and Control Design-Build Project for additional requirements.

B. Progress Drawings: These drawings shall also serve as work progress report sheets and the Design Builder shall make any notations, neat and legible, thereon daily as the work proceeds. These drawings shall be available for inspection at all times and shall be kept at the job site at a location designated by the District’s Representative.
C. As-Built Drawings:
   1. Prepare two sets of reproducible prints, based on the contract record drawings, showing “as installed” conditions thereon. It is anticipated that these drawings will be based on the shop drawings.
   2. Certify to completeness and accuracy of the “as installed” information indicated on the reproducible prints with signature.

D. Within 30 days of the date of Final Inspection, deliver the following:
   1. Record Drawings, Specification, Progress Drawings, and As-Built Drawings to the District.
   2. Approved submittals.
   3. Operators and Maintenance Manuals and warranty information.
   4. Commissioning reports.
   5. In addition to the hard copies noted in each section, submit two electronic copies in AutoCAD and PDF.

1.14 OPERATING MANUALS

A. After completion of balancing and testing and commissioning operations, instruct the District’s maintenance personnel in the operation, adjustment and maintenance of the mechanical plant for a minimum of 8 man-hours, unless the District agrees to a shorter period. See sections 01820 and 15900 for additional requirements.

B. Submit three (3) copies of certificates signed by District’s representative, attesting to their having been instructed.

C. Thirty (30) days before District’s personnel assume operation of systems, submit six (6) sets of operating maintenance instructions, indexed manuals, and parts lists for all major equipment and that requires or for which the manufacturer recommends maintenance in a specified manner.

D. Provide service manuals to the District 30 days prior to final acceptance. Manuals shall include the following information:
   1. Part numbers of all replaceable items.
   2. Manufacturer’s cuts and rating data.
   3. Oiling, lubrication and greasing data.
   4. Belt sizes, type and lengths, pulley sizes.
   5. Test and balance reports.
6. Serial numbers of all principal pieces of equipment.

7. Suppliers’ names, addresses and phone numbers.

8. Settings for all controls, both control point and throttling range.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY

A. Related Documents:

1. Drawings and general provisions of the Subcontract apply to this Section.

2. Review these documents for coordination with additional requirements and information that apply to work under this Section.

3. Furnish services, skilled and common labor, and apparatus and materials required for the complete installation as shown and within the intent of the drawings and/or these Specifications.

4. This project uses a Design Build approach. Refer to Section 230000 for Design Build Requirements.

B. Requirements of this section apply to Division 23 Sections.

C. Related Sections:

1. Agreement for Mechanical and Control Design-Build Project

2. Division 25

3. Division 26

1.02 REFERENCES

A. General:

1. The following documents form part of the Specifications to the extent stated. Where differences exist between codes and standards, the one affording the greatest protection shall apply.

2. Unless otherwise noted, the referenced standard edition is the current one at the time of commencement of the Work.

3. Refer to Agreement for Mechanical and Control Design-Build Project Project Requirements.
A. These Division 23 specifications define the statutory, administrative, procedural, and technical requirements of the mechanical and controls modifications, replacements, and/or upgrades products and services to be provided on this Subcontract.

B. Provide HVAC work as indicated on the Drawings and specified in Division 23 including:

1. Prepare coordination drawings, shop drawings, submittals, as-built drawings, and operating and maintenance instructions.

2. Determine items and quantities required.

3. Provide complete, continuous, operational, and functioning systems.

4. Fully coordinate with work of other Sections, including field verification of elevations, dimensions, clearance, and access.

5. Repair of all damage done to premises as a result of this installation and removal of debris left by those engaged in this installation.

6. Rigging, hoisting, transportation, and associated work necessary for placement of equipment in the final location shown.

7. Disassembly and re-assembly of equipment furnished under this Section, should this be required in order to move equipment into final location shown on the Drawings.

8. Labor, materials, tools, appliances and equipment that are required to furnish and install the complete installation for this section of the work including that which is reasonably inferred.

9. Cooperation with other crafts in putting the installation in place at a time when space required is accessible.

10. Temporary scaffolding necessary for performance of the work in this Division.

11. Cutting and core drilling required for work of Division 23, including locating of rebar or coordination of locating rebar with the Design Builder.

12. Pipe sleeves for all holes in walls, floors, and ceilings, and cutting of floor slabs and slabs on grade.

13. Waterproofing where necessary for installation under this Division.

14. Cooperation with and assistance to the Facilities Monitoring and Control System Design Builder as required to provide a complete and functional HVAC system.

15. Counterflashing of roof penetrations for work of Division 23.

16. Sizes, and locations for installation of any curbs and pads for work of Division 23.
17. Temporary and permanent stands and supports for equipment requiring them including vibration isolation.

18. Temporary protection of existing installation.

19. Stenciling and equipment identification.

20. Firestopping of penetrations of ducts, piping, and conduits through walls, floors, and ceiling assemblies.

21. Temporary utilities as required to install work on Division 23 including lighting, water, gas, electricity, etc.

22. Fees, permits, inspections, taxes, and approach from agencies that have jurisdiction over installation of Division 23.

23. Air and water balancing.

24. Warranty.

1.04 SUBMITTALS

A. Submit under provisions of Agreement for Mechanical and Control Design-Build Project Sections "General Requirements", and Agreement for Mechanical and Control Design-Build Project Section "Special Procedures."

B. Product Data: Submit manufacturer's technical product specification sheets for each system component and device to be provided that includes data needed to prove compliance with this specification. Clearly indicate the exact model of each component to be provided.

C. Shop Drawings: The Subcontractor shall submit for approval shop drawings prepared in accordance with Agreement for Mechanical and Control Design-Build Project Section "General Requirements", Paragraph "Shop Drawings", and as required by other sections of these specifications.

1. Shop drawings shall be drawn to a scale of 1/4 inch = 1 foot (1:25) or larger, and shall include complete dimensions, locations, elevations, and clearances for HVAC, piping, ductwork, equipment, and valve numbers.

   a. Prepare in AutoCAD 2007 format or as otherwise directed.

   b. Identify equipment using designations shown on the Contract Documents or as directed by the Owner. Do not proceed with identifications without approval from the Owner.

2. All shop drawings shall clearly call out in bold letters and cloud symbols deviations from the specifications and contract documents, no matter how minor.

D. Coordination Drawings:
1. Obtain drawings from the structural, electrical, sprinkler, plumbing, sheet metal, concrete, steel, and dry wall trades.

2. Hold regular coordination sessions with trades until coordination issues are resolved.

3. Prepare separate composite coordination drawings to a scale of 1/4 inch = 1 foot (1:25) or larger, showing work of Divisions to demonstrate coordination, clearance, access, etc. between ductwork, equipment, temperature controls, cable trays, conduits, light fixtures, piping, plumbing, structural elements, architectural elements, etc. These drawings are to be the basis for the detailed shop drawings and need not be submitted, but are to be available for review upon request.
   a. Prepare floor plans, elevations, and details to indicate penetrations in floors, walls, and ceilings and their relationship to other penetrations and installations.
   b. Each trade is to adjust their shop drawings based on the outcome of coordination sessions.

4. Indicate locations where space is limited for installation and access and where sequencing and coordination of installations are of importance to the efficient flow of the Work.

5. Indicate scheduling, sequencing, movement, and positioning of large equipment into the building during construction.

6. Indicate the proposed locations, of piping, ductwork, equipment, and materials. Include the following:
   a. Clearances for installing and maintaining insulation.
   b. Clearances for servicing and maintaining equipment, including specific ceiling tile or ceiling access panel access and space for equipment disassembly required for periodic maintenance.
   c. Equipment connections and support details.
   d. Fire-rated wall and floor penetrations.
   e. Sizes and location of required concrete pads and bases.
   f. Valve stem movement.
   g. Sizes and locations of new and existing equipment support curbs on roof.
   h. Sizes and locations of new openings, either sleeved, cut, or core-drilled, in new concrete construction unless specifically shown on the Structural Drawings.
7. Maintain one complete set of composite coordination drawings at the job site. Periodically update drawings based on actual field conditions.

8. Submit final coordination drawings as part of record document requirements.

E. Submit manufacturer's operation and maintenance manuals in compliance with Agreement for Mechanical and Control Design-Build Project Section "General Requirements", Paragraph "Operation and Maintenance Data". Include a list of spare parts that the manufacturer recommends the Owner purchase.

F. Lateral Force Anchorage: Submit lateral force anchorage calculations and details of anchorage of components to building including backing design. Seismic forces shall be in accordance with ASCE-7 requirements. Calculations shall be sealed by a Structural Engineer registered in California.

G. Record Documents: Upon completion of the work covered by this Contract, as directed, furnish the Owner with as-built drawings as specified in Agreement for Mechanical and Control Design-Build Project. Include changes installed under this Contract which are not in accordance with the Contract Drawings. Note that these as-built drawings are to be based on the Contract Drawings. In addition, submit final copies of the Shop Drawings and Coordination Drawings.

1.05 QUALITY ASSURANCE

A. Materials and Equipment: Materials and equipment shall be new. Materials and equipment for which tests have been established by Underwriter's Laboratories, Inc. shall be approved by that body and shall bear its label of approval.

1. The first names manufacturer and product is the basis of design. Other manufacturers and products are considered as substitutions.

B. In lieu of listing by an approved testing laboratory, consideration will be given to certified test reports of an adequately equipped, recognized independent test laboratory competent to perform such testing indicating conformance to requirements of the applicable Underwriter's Laboratories, Inc. standards.

C. Unless otherwise approved by the Project Manager, the materials to be furnished under this specification shall be the standard products of manufacturers regularly engaged in the production of such equipment equal to or superior to the material specified, and shall be the manufacturer's latest standard design that complies with the specification requirements.

D. Approval of Materials:

1. Agreement for Mechanical and Control Design-Build Project Section "General Requirements" requirements for "Materials and Equipment" and "Submittals".

2. A complete list of materials and equipment proposed shall be submitted to the Project Manager for approval. The list shall include for each item: the manufacturer, the manufacturer's catalog number, type or class, the rating, capacity, size, etc.
3. Before installation of the equipment, the Subcontractor shall submit for approval detailed construction drawings for each item of fabricated equipment required for installation. Drawings shall be to scale and fully dimensioned and shall provide sufficient detail to clearly indicate the arrangement of equipment and its components.

4. Installation of approved substituted equipment is the Subcontractor's responsibility, and changes required to work included under other divisions for installations of approved substituted equipment must be made to the satisfaction of the Owner and without change in contract price. Approval by the Owner of substituted equipment and/or dimension drawings does not waive these requirements.

1.06 START-UP TRAINING

A. Assist Owner in preparing a formal training program for operating staff prior to the scheduled start-up date. The program will consist of the design, start-up, and operation of the mechanical, plumbing, fire protection, and building automation systems. Coordinate the training program with the production of the operation and maintenance manuals. Provide indexed binder and training materials to each participant.

B. Provide 16 hours (unless specified otherwise) of on-site training in the operation and maintenance for installed system and major piece of equipment. Systems include boilers and heating hot water system, chillers and chilled water system, plumbing, fire protection, air supply and exhaust systems, air conditioning units, balancing, and Facilities Monitoring and Control System. Trainers shall be experienced, manufacturer-approved personnel.

1. Schedule training for each system in advance with the Owner.

2. Include travel, per diem and incidental costs for personnel under contract to the Subcontractor.

3. Operations and Maintenance data to be available for training sessions.

1.07 RULES AND REGULATIONS

A. See Agreement for Mechanical and Control Design-Build Project.

B. Provide work and materials in full accordance with the latest rules of the organizations listed in Agreement for Mechanical and Control Design-Build Project and in other Sections of Division 23, and with prevailing rules and regulations pertaining to adequate protection and/or guarding of moving parts, or otherwise hazardous locations.

C. Whenever the Drawings and Specifications require something which will violate the regulations, the regulations shall govern. Review the Drawings and Specifications, and request from the Owner clarification or revision of portion of the work in violation of the rules or regulations prior to installing the work. Necessary installation alteration required for compliance shall be made at no additional cost to the Owner.
D. Whenever the Drawings and Specifications require larger sizes, or higher standards than are required by the regulations, the Drawings and Specifications shall govern.

E. Strictly conform to the requirements of the National Fire Protection Association, National Electrical Code, California Title 24 Codes, OSHA, Fire Marshal, and insurance underwriters’ requirements. Expenses required shall be borne under this Contract.

1.08 PROTECTION OF EQUIPMENT

A. Protect, handle, and store products under provisions of Agreement for Mechanical and Control Design-Build Project.

B. Assume responsibility for damage to of the work or premises before substantial completion. Should new or existing equipment become damaged, restore it to its original condition and finish before final acceptance. Damage incurred to the Owner property or to the work of other Divisions, caused by this Division, shall be replaced or repaired by, and at the expense of, the Subcontractor to the satisfaction of the Owner. Exposed materials shall be clean at the time of acceptance of the project.

1.09 EXISTING SYSTEMS AND UTILITIES SHUT-DOWN

A. During the entire course of construction, existing HVAC, Plumbing and Fire Protection system shall remain in operation. Shutting down of these systems shall not be permitted except for designated periods. The date, time, and duration for systems shut-downs shall be requested in writing by the Design-Builder, approved by the District, and the Design-Builder shall be advised of same in advance. During these shut-down periods, all connections to existing piping, ductwork, and wiring shall be made and completed. Piping and ductwork shall be premeasured, prefabricated, and pretested ready for final connection in order to keep shutdown time to absolute minimum. Overtime shutdowns shall be at no extra cost to the District. Refer to Section 01500.

B. Provide temporary by-pass piping, ductwork and blankoff plates, and wiring, whether shown or not, as required to keep systems in continuous operation at times other than shutdown period; while portions of the systems are being worked on.

C. No system shutdown shall be permitted without he expressed written approval from the District. The Design-Builder shall plan the shutdowns 2 weeks in advance. Design-Builder shall submit to the District requests for each shutdown. The request shall state what systems is to be shutdown, what areas will be affected, how long the period will be, and what contingency plan is provided if the work cannot be completed within the specified time. This procedure must be established and followed in order to provide the District with the least amount of service interruption and the least amount of disturbance for the users of the affected areas.

D. All system or utilities shut-downs shall be performed by the District.

1.10 SCHEDULING AND SEQUENCING

A. Cooperate with other trades in putting this installation in place at a time when space required is accessible, and in such a manner that other work in this space may be installed as shown on the Drawings. Schedule work and cooperate with the others to
avoid delays, interferences, and unnecessary work, conforming to the construction schedule, making the installation when and where directed.

1. Include labor and materials to install certain items furnished under this contract when required by the schedule. These items are part of this contract but may need to be installed only after completion of work under another contract which this Design Builder may or may not be participating in. It is the responsibility of this contract to coordinate with others to insure that preparations are made and ready to accept the installation of these items. These items include, but are not limited to:

   a. Air inlets and outlet
   b. Temperature sensors.
   c. Monitoring and control panels.
   d. Sprinkler heads.

B. If a discrepancy is discovered between engineering and architectural Drawings, whether with respect to a significant variance between location, variation in quantity, or violation of code requirements, notify Architect for clarification and do not proceed with the work affected until clarification has been made.

C. Schedule work in advance with the Owner. No system shall be shutdown unless approved in writing.

1.11 TEMPORARY USE

A. Should it become necessary to use the new portion of the system and the new equipment to warm or air condition part of the building before the completion of this work, the Owner reserves the right to make use of same at its own risk and expense, but the temporary use of the equipment shall not constitute an acceptance of the plant or part thereof in way. The Owner will bear the cost of fuel and electrical current for such temporary use of the equipment. If temporary use of new systems or equipment is solely for the benefit of the Design Builder, Design Builder shall bear the cost of fuel and electrical current for such temporary use.

1.12 WARRANTY

A. Comply with Agreement for Mechanical and Control Design-Build Project Section “General Requirements.”

B. Provide extended warranties where specifically required in subsequent sections of Division 23.
PART 2 - PRODUCTS

2.01 GENERAL

A. In addition to material and equipment specified, provide incidental materials to effect a complete installation. Such incidental materials include solders, tapes, caulking, mastics, gaskets and similar items.

B. Materials and equipment shall be uniform throughout the installation. Equipment of the same type shall be of the same manufacturer. Materials and equipment shall be new.

2.02 MATERIALS AND SUBSTITUTIONS

A. Comply with Agreement for Mechanical and Control Design-Build Project Section "General Requirements - Specified Items and Substitutes."

PART 3 - EXECUTION

3.01 EXAMINATION OF SITE

A. Examine the site and become familiar with conditions that may affect the work covered by this division of the Specifications.

B. Arrange to meet with the Owner at the job site before the work is started and discuss with them the various phases of the work and the procedure and preparation for testing and adjusting the systems.

C. The general arrangement and location of piping ductwork, apparatus, etc., is shown on the Drawings or herein specified. Minor changes may be necessary to accommodate other work, new or existing, that may conflict with this work. Install this work in harmony with these trades and fully coordinate work.

D. Visit the site of the work, take measurements, examine areas where work is to be performed and get such other information necessary for proper execution of the work. Ascertain and check conditions with the Drawings and Specifications, other trades, existing conditions and by what means the work is to be performed. No allowance shall subsequently be made for extra expense due to failure or neglect to make such examination and correlation. Where revisions or changes in the existing work are required to permit the installation of new work, they shall be made at no additional cost to the Owner. No allowance shall be subsequently made for error or omission.

3.02 ACCURACY OF DATA

A. The Drawings indicate the general arrangement and location of piping, ducts, and equipment. Should it be necessary to deviate from arrangement or location indicated in order to meet architectural conditions or site conditions, or due to interference with other work, make such deviations as offsets, rises and drops in piping and ducts that may be necessary, whether shown or not, without extra expense to the Owner. Extreme accuracy of the data given herein and on the Drawings is not guaranteed. The Drawings
and Specifications are for the assistance and guidance of this Section and exact locations, distances, and elevations shall be governed by actual site conditions.

B. Develop/modify the drawings to suit field conditions and project requirements.

3.03 COORDINATION ITEMS

A. Coordinate mechanical work with that of other trades in order to:

1. Avoid interferences between general construction, mechanical, electrical, structural and other specialty trades.

2. Maintain clearances and advise other trades of clearance requirements for operation, repair, removal and testing of mechanical equipment.

3. Indicate aisle-ways and access-ways required on coordinated shop drawings for roof equipment area, mechanical equipment rooms, data and telecomm rooms, corridors, ceiling spaces, shafts, corridors, ceiling space, laboratories, etc.

B. Understanding of Work:

1. Study, examine, and compare of the contract documents, including drawings and specifications. The Subcontractor shall have a full understanding of how the work in this part is scheduled, phased, and installed with work of other trades.

2. Include in this installation piping, ductwork, devices, and equipment that are necessary for complete and operating systems as specified and as required.

3. Connect piping and ductwork from fixtures, outlets, and devices full size to the nearest suitable main or riser.

4. Certain installations may be presented as typical, and full details are not repeated for each case. Subcontractor shall provide complete installation as if full details apply to each and every case, and make adjustments to typical details to suit each specific installation as part of the basic work.

5. Installation of work presented on the diagrams are applicable to the plans, and work depicted on the plans are applicable to the diagrams.

6. If there is a discrepancy in the drawings or specifications, the Design Builder shall figure the work based on the most stringent requirements to complete the installation and obtain clarification from the Architect before installation.

C. Sequence, coordinate, and integrate the various elements of mechanical systems, materials, and equipment. Comply with the following requirements:

1. Coordinate mechanical systems, equipment, and materials installation with other building components.

2. Verify dimensions by field measurements.
3. Arrange for chases, slots, and openings in other building components during progress of construction, to allow for mechanical installations.

4. Coordinate the installation of required supporting devices and sleeves to be set in poured-in-place concrete and other structural components, as they are constructed.

5. Sequence, coordinate, and integrate installations of mechanical materials and equipment for efficient flow of the Work. Give particular attention to large equipment requiring positioning prior to closing in the building.

6. Where mounting heights are not detailed or dimensioned, install systems, materials and equipment to provide the maximum headroom possible. Work shall be above ceilings or ceiling line.

7. Coordinate installation and connection of mechanical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies. Provide required connection for each service.

8. Install systems, materials, and equipment to conform with approved submittal data, including coordination drawings, to greatest extent possible. Conform to arrangements indicated by the Contract Documents, recognizing that portions of the Work are shown only in diagrammatic form. Coordinate with individual system requirements.

9. Install systems, materials, and equipment level and plumb, parallel and perpendicular to other building systems and components, where installed exposed in finished spaces.

10. Install mechanical equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. As much as is practical, connect equipment for ease of disconnecting, with minimum of interference with other installations. Extend grease fittings to an accessible location.

11. Install systems, materials, and equipment giving right-of-way priority to systems required to be installed at a specified slope.

12. Coordinate with the locations of electrical panels and avoid installing piping and ductwork over them. Electrical panels are purposely located and have priority for location. The Design Builder is responsible for required piping and ductwork offsets to insure that the panels are located as designed and for other conditions.

13. Perform system modification recommended by Test and Balance Agency after recommendations are accepted by the Owner

3.04 WORKMANSHIP AND SUPERVISION

A. Comply with the following:
B. General Requirements, Agreement for Mechanical and Control Design-Build Project Section "General Requirements - Coordination of Work."

C. Special Requirements Agreement for Mechanical and Control Design-Build Project Section "Special Procedures - Quality Control", in addition to the following.

1. Measurements: Materials installed shall be to exact field measurements.

2. The installation depicted on the Drawings is designed to fit tightly into work under other Sections or Divisions. It is the essence of this Contract that work be completely coordinated with other Sections or Divisions, and that locations of pipes and ducts be exactly determined in the field and cleared with other Sections or Divisions before the installation of these items is begun. No extra compensation will be made for failure to observe this clause.

3. Adequate clearance for access to operable devices and automatic devices and for access to lubrication points shall be maintained in portions of the work including ductwork and piping installed on the roof. Tripping hazards shall be avoided.

4. Provide architectural access doors where shown and where required for access to equipment and operable devices.

5. Gauges, thermometers, and other indicating devices shall be installed so that they can be easily read from the floor.

3.05 MATERIAL DELIVERY AND STORAGE

A. Comply with Agreement for Mechanical and Control Design-Build Project Section "Special Procedures - Delivery."

B. Comply with Agreement for Mechanical and Control Design-Build Project Section "Special Procedures - Storage."

3.06 INSTALLATION

A. Manufacturer's Directions: Follow manufacturer's directions covering points not shown on the drawings or specified herein. Manufacturer's directions do not take precedence over drawings and Specifications. Where these are in conflict with the drawings and Specifications, notify the Project Manager for clarification before installing the work.

B. Carpentry, Cutting, Patching, and Core Drilling:

1. Provide carpentry, cutting, patching, and core drilling required for installation of material and equipment specified in this division.

2. No penetrations shall be sleeved, cut, or core drilled through concrete construction without a submittal indicating exact locations and sizes and specific written approval from the Owner or unless specifically shown on the Structural Drawings.
3. It is the Subcontractor’s responsibility to accurately size and locate openings through the structure. The dimensions shown on the Structural Drawings are for general information only. Provide specific sizes, dimensions, requirements, etc.

C. Seismic Mounting:

1. Material and equipment, including floor mounted equipment, piping, and appurtenances shall comply with Code requirements.

D. Waterproof Construction:


2. Provide waterproof NEMA 3R enclosures for equipment or devices mounted outside or otherwise exposed to the weather.

E. Sleeves, Stubs, and Slab Penetrations: Division 23 Section "Hangers and Supports for HVAC Piping and Equipment".

F. Painting of Mechanical Equipment and Hardware:

1. Comply with applicable Division 09 sections for paints and coatings.

2. Provide moisture resistant paint for exterior painting.

3. Colors shall be as shown on the drawings unless specified.

4. Comply with individual Sections for other equipment to be painted.

5. Repair damaged galvanizing, paint, or coatings. Use Z.R.C. (no known equal) cold galvanized compound for galvanized repairs.

G. Concrete Equipment Bases:

1. All equipment located on concrete floor inside the building or on grade outside the building, shall be mounted on a concrete base. The concrete base shall be four inches high and shall extend six inches beyond the edge of equipment base unless indicated otherwise on drawings.

2. Coordinate concrete bases: Concrete bases indicated on Architectural or Structural drawings are specified in other Divisions. Concrete bases not on Architectural or Structural drawings are requirements of this Division.

3.07 PIPING AND EQUIPMENT IDENTIFICATION

A. Comply with Division 23 Section "Identification for HVAC Piping and Equipment."
3.08 NOISE AND VIBRATION

A. The target room NC sound levels for the operating HVAC system is as follows:

<table>
<thead>
<tr>
<th>Room Type</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theatre</td>
<td>30</td>
</tr>
<tr>
<td>Lobby</td>
<td>40</td>
</tr>
<tr>
<td>Auditorium/Conference Rooms</td>
<td>30</td>
</tr>
<tr>
<td>Corridors/Utility Areas</td>
<td>45</td>
</tr>
<tr>
<td>Open Offices</td>
<td>40</td>
</tr>
<tr>
<td>Private Offices</td>
<td>35</td>
</tr>
<tr>
<td>Classrooms</td>
<td>30</td>
</tr>
</tbody>
</table>

B. Vibration levels shall not exceed vibration criteria listed in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment".

C. If noise or vibration problems are a result of improper material or installation, or exceeds limits by Paragraphs - 3.03.A and 3.03.B, these conditions shall be corrected by the Subcontractor at no cost to the Owner.

3.09 SHUTDOWN AND SCHEDULING

A. Comply with Agreement for Mechanical and Control Design-Build Project "Special Procedures - Shutdown."

3.10 PROTECTION OF EQUIPMENT

A. Care shall be exercised during construction to avoid damage or disfigurement. Equipment shall be protected from dust and moisture prior to and during construction. The Subcontractor is cautioned that concrete finishing, painting, etc. in electrical rooms shall not proceed if unprotected equipment is installed.

B. Where required or directed, construct temporary protection for equipment and installations for protection from dust and debris caused by construction.

C. All protection shall be substantially constructed with the use of clean canvas, heavy plastic, visqueen and plywood as required, and made tight and dust proof as directed.

D. The Subcontractor shall repair by spray or brush painting, after properly preparing the surface, scratches or defects in the finish of the equipment. Only identical paint furnished by the equipment manufacturer shall be used for such purposes.

E. Failure of the Subcontractor to protect the equipment as outlined herein shall be grounds for rejection of the equipment and its installation.
3.11 INSPECTIONS

A. Comply with Special Requirements, Agreement for Mechanical and Control Design-Build Project Section "Special Procedures - Inspections."

3.12 CLEANING

A. Comply with Agreement for Mechanical and Control Design-Build Project Section "Special Procedures - Cleaning."

3.13 LUBRICATION

A. All lubrication points shall be accessible. Where this is impossible, provision shall be made for lubrication at an accessible location. Where oil is used, an oil level indicator and capped, vented filling connection shall be provided and firmly mounted in an accessible space and shall be connected to the bearing with pipe(s) as required. Where grease is used for lubricant, the pipe shall have a suitable lubricating fitting installed at the accessible end. Equipment shall be thoroughly lubricated before operation and at time work is accepted.

3.14 SEALANTS

A. See Division 07 Sections for sealing duct, pipe, and conduit penetrations through walls, partitions, and floors.

1. Completely seal duct, pipe and conduit penetrations through rated and non-rated walls.

3.15 TESTS

A. Upon completion of the mechanical construction work, perform tests and provide test reports as specified in this and other sections.

1. All tests shall be made in the presence of a representative of the Project Manager. The application or interruption of mechanical utilities shall be programmed and directed by the Project Manager.

2. The Subcontractor shall submit to the Project Manager 3 copies of test results, certified in writing, witnessed, signed and dated, immediately upon completion of work. Unsatisfactory condition revealed by these test results, or unsatisfactory methods of tests and/or testing apparatus and instruments, shall be corrected by the Subcontractor to the satisfaction of the Project Manager.

3. The Project Manager reserves the right to require that the Subcontractor perform and repeat tests that are deemed necessary to complete or check the tests or the certified records of the Subcontractor during the course of the work. Correct unsatisfactory portion of its work that is revealed by the tests or that may be due to progressive deterioration during this period, unless the item in question was a direct specification.
3.16 MAINTENANCE AND OPERATING INSTRUCTIONS AND TRAINING

A. Refer to Agreement for Mechanical and Control Design-Build Project Section "General Requirements", for maintenance and operating instructions, and training requirements.

B. At time of occupancy, arrange for manufacturer's representatives to instruct operating and maintenance personnel in the use of equipment requiring operating and maintenance. Arrange for personnel to be instructed at one time. Costs for this service shall be included in the Subcontract.

C. Maintenance and operating instructions and training for Owner-furnished equipment will be provided by the equipment vendor. The Subcontractor shall be responsible for other equipment.

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY

A. Related Documents:
   1. Drawings and general provisions of the Subcontract apply to this Section.
   2. Review these documents for coordination with additional requirements and information that apply to work under this Section.
   3. Inertia bases

B. Related Sections:
   1. Agreement for Mechanical and Control Design-Build Project
   2. The requirements of this section apply to Division 23 Sections.

1.02 REFERENCES

A. General:
   1. The following documents form part of the Specifications to the extent stated. Where differences exist between codes and standards, the one affording the greatest protection shall apply.
   2. Unless otherwise noted, the referenced standard edition is the current one at the time of commencement of the Work.
   3. Refer to Agreement for Mechanical and Control Design-Build Project.
   4. Refer to Division 23 Section "Common Results for HVAC" for codes and standards, vibration and noise, and other general requirements.

1.03 SUBMITTALS

A. Submit under provisions of Division 23 Section "Common Results for HVAC - Review of Materials" and Agreement for Mechanical and Control Design-Build Project.

B. Product Data:
1. Provide specific information for items described under the products section of this Specification, including specifications, descriptive drawings, catalog cuts, and descriptive literature, including make, model, dimensions, weight and interface description with other work, and indicating full compliance with specifications as outlined.

2. An itemized list showing items to be isolated, the isolator type, model number, isolator loading and deflection, and reference to specific drawing showing frame construction where applicable.

C. Shop Drawings:

1. Indicate inertia bases and vibration isolator locations, with static and dynamic load on each.

2. Drawings showing intended locations.

3. Drawings showing equipment frame construction for each machine, including dimensions, structural member sizes, and support point locations.

4. Drawings showing methods for suspension, of support, and guides.

5. Drawings showing methods for isolation of piping, at penetrations of walls, slabs, etc.

6. Submit calculations for all vibration isolators, supports and bracings, stamped and signed by a California licensed structural engineer.

D. Maintenance and Operations Data: Submit manufacturer's certificate that isolators are installed and adjusted to meet or exceed specified requirements.

1.04 QUALITY ASSURANCE

A. Maintain ASHRAE recommended noise criteria for average noise levels for equipment at full-load condition.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Isolation equipment shall be supplied by a single manufacturer. Model numbers given below are Mason's. Vibration isolation components (isolators, snubbers, rails, and inertia bases) to be hot-dip galvanized. Welded steel channel perimeter frame with welded-in reinforcing bars, pre-located welded-in anchor bolts or pre-located bolt holes suitable for the number and size required, and height saving brackets where required. Snubbers shall be provided. Unless otherwise noted, delete inertia base requirement if the equipment is provided with motor rating of less than 15 hp and is provided with steel frame base.
B. All vibration isolation components (isolators, snubbers, rails, and inertia bases) to be hot-dip galvanized.

C. Acceptable Manufacturers
   1. Mason Industries
   2. M.W. Sausse
   3. Kinetics

2.02 VIBRATION ISOLATORS

A. General:
   1. Metal parts of vibration-isolation units shall be as follows:
      b. Hardware (washers, nuts, bolts, etc.): Galvanized outdoors, and inside air handlers, and cadmium plated indoors.
      c. Springs:
      d. Neoprene coated outdoors and inside air handlers
      e. Painted indoors.
   2. Isolator types are scheduled to establish minimum standards. At the Subcontractor's option, accessories can be an integral part of isolators supplied to provide initial lift of equipment to operating height, hold piping at fixed elevation during installation and initial system filling operations, and similar installation advantages. Accessories shall not degrade the vibration isolation system.
   3. Static deflection of isolators are indicated in Vibration Isolation Schedule. Static deflections stated are the minimum acceptable deflection for the mounts under actual load.
   4. The use of nested springs or of multiple parallel springs within a single mount is not permitted.

B. Unit FSN (Floor Spring and Neoprene):
   1. Spring isolators to be free-standing and laterally stable without housing. Spring diameter of steel springs shall be not less than 0.8 times the compressed height of the spring at the design load. Springs shall have a minimum additional travel to solid equal to 50 percent of the actual deflection. Springs shall be so designed...
that the ratio of horizontal stiffness to vertical stiffness is approximately 1. Mounts shall have leveling bolts.

2. The spring element in the isolator shall be set in a neoprene cup and have a steel washer to distribute the load evenly over the neoprene. A rectangular bearing plate of appropriate size to load the pad uniformly in the range of 40 to 50 psi shall be provided. A neoprene friction pad, a stainless steel, aluminum, or galvanized steel plate shall be used between the friction pad and the isolator. The isolator, separator plate, and friction pad shall be permanently adhered to one another and to the bottom of the bearing plate.

3. Unit FSN isolators shall be Mason Model SLF, Kinetics Model FDS, M.W. Sausse, or equal.

C. FSS (Floor Seismic Spring):

1. Vertically-restrained spring isolators similar to type FSN specified herein before, with the addition of a metal housing with neoprene grommets around the restraining bolts which prevent metal-to-metal contact.

2. Unit FSS isolator shall be Mason Model SLR, Kinetics FLS, M.W. Sausse, or equal.

3. Isolators shall be installed in a manner that allows adjustment of horizontal alignment to allow centering of restraining bolts to prevent metal-to-metal contact or metal to grommet contact.

D. Unit HS (Hanger Spring):

1. Vibration-isolation hangers shall consist of a free-standing laterally stable steel spring set into a neoprene cup, contained within a steel housing. The neoprene cup shall be manufactured with a grommet (or other element) to prevent the hanger rod from contacting the hanger housing. A steel washer shall be provided in the neoprene cup to evenly distribute load onto the neoprene.

2. The plate or washer at the top of the spring shall be welded to the spring. The hanger rod shall be securely fastened to this plate or washer using lock nuts. The hanger rod shall have a diameter not less than 5/8 inch. This design represents a modification to the unit types given below. The modification is intended to limit the side-to-side motion of the hanger rod relative to the hanger casing.

3. Spring diameter and hanger housing lower hole sizes shall be large enough to permit the hanger rod to swing through a 30 degree arc before contacting the housing. Spring elements shall have minimum additional travel to solid equal to 50 percent of the actual deflection.

E. Unit NP (Neoprene Pad)

1. Ribbed or waffled 40-50 durometer neoprene pads rated at 40-50 PSI loading and 0.125 inch deflection.
2. Mason Super "W", Kinetics NGD, or equal.

3. Upper hanger rod attachment shall be made through a neoprene rubber-in-shear element designed to avoid direct contact between the hanger rod and the isolator frame.

4. Springs shall be color coded for ease of identification and removable, for field connection.

5. Unit HS isolators shall be Mason Model 30N, Kinetics Model SH, M.W. Sausse, or equal.

2.03 EQUIPMENT BASES

A. Unit BSF (Base Steel Frame):

1. Steel Base Frames shall consist of structural steel sections sized, spaced, connected, and cross-connected to form a rigid base which will not twist, deform, or deflect in any manner that will negatively affect the operation of the supported equipment or the vibration-isolation mounts. Frames shall be adequately sized to support basic equipment units and mounts plus associated pipe elbow supports, duct elbow supports, electrical control elements, or other components closely related and requiring resilient support in order to prevent transfer of vibration energy to the building structure. The depth of steel frame bases shall be at least 1/10 the longest dimension of the base with a minimum depth of 6 inches (150 mm), but not more than 12 (300 mm) inches. Frame bases shall include side mounting brackets for attachment to vibration isolators. Mounting brackets shall be located on the sides of the base that are parallel to the axis of rotation of the supported equipment to maximize horizontal and rocking stability.

2. Unit BSF base shall be supplied by the isolator manufacturer and shall be Mason Type WFSL, Kinetics Type SFB or SRB, M.W. Sausse, or equal.

2.04 SEISMIC RESTRAINT

A. Unit SN (snubber):

1. Snubbers to limit the vertical and horizontal motion of the isolated equipment shall be fabricated from steel. A neoprene pad, 1/4-inch minimum thickness, shall be affixed at the point of contact. There will be no contact between snubbers and the inertia base or equipment support frame during normal operation. Minimum of one snubber per side, four total, shall be required on each base. Seismic snubbers shall have a minimum of 1.0Gratings and anchorages.

2. Snubbers shall not be finally installed until vibration isolators are in place and adjusted with actual operating loads.

3. Snubbers shall be Mason Z-1225, Kinetics HS-4, M.W. Sausse, or equal.

B. Unit SC (steel cable):
1. Steel cables should be capable of handling supported load plus seismic load.
2. Cables should be arranged to achieve all directional restraint.
3. Cable should have sufficient slack to avoid short circuiting the vibration isolators.
4. Unit SC shall be Mason Type SSC, Kinetics, M.W. Sausse, or equal.

2.05 PIPING ISOLATORS

A. Specialty Products Co. Acousto-Plumb isolators for pipe ¾ inch (20 mm) and smaller, and Trisolator for pipes 1 inch (25 mm) and larger, or equal.

B. Flexible Connectors: See Section 232120, “Hydronic Specialties”.

PART 3 - EXECUTION

3.01 GENERAL

A. The Subcontractor is to obtain inspection of installation to be covered or enclosed prior to such closure.

B. The Subcontractor is to obtain written and/or oral instructions from the vibration isolation manufacturer as to the proper installation and adjustment of vibration isolation devices.

C. The Subcontractor is to correct, at no additional cost, installations which are deemed defective in workmanship or materials.

D. The Subcontractor is responsible for proper operation of systems, minor sub-systems, and services provided under this Section. The Subcontractor is to coordinate startup procedures, calibration, and system check-out with Subcontractors involved. Any system operational problems shall be diagnosed. Correctional procedures shall be initiated by the various Subcontractors as required to bring the system into compliance with the design, and the problem shall then be rechecked to verify that the system operates normally. Any remaining difficulties shall be brought to the attention of the District.

E. Do not install equipment, ductwork, piping and conduit which makes rigid contact with the structure unless it is allowed by this specification.

F. Piping connections between isolated equipment and building structure shall be with single or twin sphere flexible connectors, braided flexible connectors, etc., as specified and/or indicated.

G. The Subcontractor is to bring to the District's attention prior to installation conflicts which will result in unavoidable contact between the building structure and the isolated equipment, piping, etc., described herein, due to inadequate space, etc. Corrective work necessitated by conflicts after installation is at the expense of the Subcontractor.

H. The Subcontractor is to bring to the District's attention prior to installation discrepancies between the requirements of this Specification and field conditions, changes required due
to specific equipment selection, etc. Corrective work necessitated by discrepancies after installation is at the expense of the responsible Subcontractor.

I. Provide new seismic bracing on existing equipment, ductwork and piping where indicated.

3.02 ISOLATOR INSTALLATION

A. The installation or use of vibration isolators must not cause change of position of equipment, conduit, piping or ducting, which would result in stresses in connections or misalignment of shafts or bearings. In order to meet this objective, maintain equipment and attached systems in a rigid position during installation. The load shall not be transferred to the isolator until the installation is complete and under full operational load.

1. Plumbing, piping, and ducting at mechanical equipment connections is to be fully supported by specified hangers.

2. Mechanical equipment and vibration mounts shall not carry plumbing, piping, or ducting loads.

3. Utilize flexible metal, liquid-tight conduit for electrical connections.

4. Provide at least 180-degree bend in flexible electrical connections between un-isolated and isolated equipment.

B. Isolation/Absorption Products: The completed installation must be free of vibration and noise. Systems, equipment, or parts which vibrate or generate vibration unduly, or which generate or emit undue noise while in operation shall:

1. Be adjusted, repaired or replaced as appropriate to obtain acceptable levels of vibration or noise, or

2. Be supported on, or fitted with, suppression or absorption devices or other means, which effectively prevent the transmission of vibration or noise beyond the offending item.

C. Equipment Isolator Installation:

1. Use space saver brackets for equipment supported on Type FSN vibration isolators.

2. The minimum operating clearance between the underside of the frame or inertia base and the pad or floor is 1 inch.

3. Place the frame in position and support temporarily by shims prior to the installation of the machine or isolators.

4. After the entire system installation is completed and under full operational load, adjust the isolators so that the load is transferred from the shims to the isolators, and that the shims are barely free. Remove the shims.
5. Seismic snubbers shall not be finally installed until vibration isolators are in-place and adjusted with actual operating loads.

6. Seismic snubbers shall be completely free of contact between isolated and unisolated portions in all directions of motion and rotation

D. Isolator Hangers:

1. The isolators shall be installed with the isolator hanger box as close as possible to the building structure, e.g. at the top of hanger rods.

2. The isolators shall be suspended from beams, or overhead slab.

3. Orientation of isolator assembly including support and load rods shall be within five degrees of vertical.

4. Design Builder shall assure that hanger isolators are not mechanically shorted due to cocking of spring, and that hanger rod is centered in hanger box.

E. Pipe Flexible Connections:

1. Provide flexible connectors between isolated and un-isolated mechanical equipment. Flexible connectors shall be compatible with pressure, temperature, and fluid

3.03 EQUIPMENT ISOLATION

A. Install isolators for fans, vacuum pumps, fan coil units, compressors, pumps and other such equipment as shown on Vibration Isolation Schedule or as otherwise required.

B. Approve completed vibration isolation system for isolated equipment.

3.04 PIPING ISOLATION

A. Where specifically indicated only, use specified pipe isolation system.
### VIBRATION ISOLATION SCHEDULE

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Base Type and Weight(^{(1)})</th>
<th>Isolator Type</th>
<th>Minimum Static Deflection Under Load (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boilers:</td>
<td>NA</td>
<td>NP</td>
<td>NA</td>
</tr>
<tr>
<td>Packaged Rooftop AC Unit</td>
<td>(2)</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Pumps</td>
<td>NA</td>
<td>NP</td>
<td>2</td>
</tr>
<tr>
<td>Chiller</td>
<td>NA</td>
<td>NP</td>
<td>NA</td>
</tr>
<tr>
<td>Roof-Mounted Fans:</td>
<td>NA</td>
<td>NP</td>
<td>2 (50 mm)</td>
</tr>
<tr>
<td>Air Handler</td>
<td>(2)</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Hung Fans and AC Units</td>
<td>NA</td>
<td>HS &amp; SC</td>
<td>1 (25 mm)</td>
</tr>
<tr>
<td>Floor Mount Fan Coil</td>
<td>BSF</td>
<td>FSN</td>
<td></td>
</tr>
<tr>
<td>AC Units (Outdoor section)</td>
<td>NA</td>
<td>NP</td>
<td></td>
</tr>
</tbody>
</table>

**General Note:**

A. The information table above is recommendations; provide calculations and analysis to determine the final selection and configurations of the equipment.

\(^{(1)}\) 1X = 1 time the weight of the equipment supported.

2X = 2 times the weight of the equipment supported.

NA = Not applicable

\(^{(2)}\) The entire unit shall be mounted isolation curb. Isolation curb is not required if unit has internally isolated fans with the same static deflection.

### BALANCING OF ROTATING EQUIPMENT

A. Comply with Division 23 Section "Testing, Adjusting, and Balancing for HVAC"

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY

A. Related Documents:
   1. Drawings and general provisions of the Subcontract apply to this Section.
   2. Review these documents for coordination with additional requirements and information that apply to work under this Section.

B. Section Includes:
   1. Identify all installed mechanical distribution piping, mechanical equipment and components.

C. Related Sections:
   1. Agreement for Mechanical and Control Design-Build Project
   2. Division 09 Section "Painting" for identification painting.

1.02 REFERENCED STANDARDS

A. General:
   1. The following documents form part of the Specifications to the extent stated. Where differences exist between codes and standards, the one affording the greatest protection shall apply.
   2. Unless otherwise noted, the referenced standard edition is the current one at the time of commencement of the Work.
   3. Refer to Agreement for Mechanical and Control Design-Build Project.
   4. Refer to Division 23 Section "Common Results for HVAC" for codes and standards, and other general requirements.

B. ANSI/ASME –American National Standards Institute/Society of Mechanical Engineers:
   1. ASNI/ASME A 13.1 Scheme for the identification of piping systems
1.03 SUBMITTALS

A. Submit under provisions of Division 23 Section "Common Results for HVAC, Review of Materials" and Agreement for Mechanical and Control Design-Build Project Section "General Requirements."

B. Submit list of wording, symbols, letter size, and color coding for mechanical identification.

C. Submit valve chart and schedule, including valve tag number, location, function, and valve manufacturer's name and model number.

D. Submit valve database as per Part 3.05 - Stenciling and Identification, D.3 - Valve Tags.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. W. H. Brady, Seton or Almatek products.

B. No substitutions.

2.02 MATERIALS


B. Plastic nameplates: laminated two-layer plastic with engraved black letters on light, contrasting background color.

C. Plastic tags: laminated three-layer (double-sided) plastic with engraved black letters on light, contrasting background color. Tag size at least 1-1/2 inch (38 mm) diameter.

D. Stencils: with clean-cut symbols and letters of following size:

<table>
<thead>
<tr>
<th>Outside Diameter of Insulation or Pipe</th>
<th>Color Field Length</th>
<th>Letter Height</th>
</tr>
</thead>
<tbody>
<tr>
<td>¾ to 1-1/4 inches (9.5 to 31.7 mm)</td>
<td>8 inches (200 mm)</td>
<td>½ inch (13 mm)</td>
</tr>
<tr>
<td>1-1/2 to 2 inches (38.1 to 50.8 mm)</td>
<td>8 inches (200 mm)</td>
<td>¾ inch (20 mm)</td>
</tr>
<tr>
<td>2-1/2 to 2 inches (63.5 to 50.8 mm)</td>
<td>12 inches (300 mm)</td>
<td>1 ¼ inch (32 mm)</td>
</tr>
<tr>
<td>8 to 10 inches (203.2 to 254 mm)</td>
<td>24 inches (600 mm)</td>
<td>2 ½ inch (64 mm)</td>
</tr>
<tr>
<td>Over 10 inches (254 mm)</td>
<td>32 inches (800 mm)</td>
<td>3 inches (75 mm)</td>
</tr>
<tr>
<td>Ductwork and equipment</td>
<td>---</td>
<td>2 ½ inch (64 mm)</td>
</tr>
</tbody>
</table>

E. Stencil paint: semi-gloss enamel; in accordance with Division 09 Section "Painting".
F. Plastic pipe markers: factory fabricated, flexible, semi-rigid plastic, preformed to fit around pipe or pipe covering; minimum information indicating flow direction arrow and fluid being conveyed.

1. Special gases shall be identified using markers with yellow background and black letters, direction arrow, and full chemical names and symbols.


H. Equipment tags: Metal tags, Almetek TH-9A with 500-series consisting of Almetek industries 9-character aluminum holder #TH-9A with 500-series characters, black on yellow background. Format is 2 characters for building # (15), space, 2 or 3 characters for equipment type (AC, AHU, etc.), space, three-digit equipment number (001, etc.). These tags can be ordered in parts and site-assembled, or pre-assembled from the factory. Attachment is by a pair of rivets, screws, or bolts onto the equipment to be identified; for water meters and similar equipment installed in piping, a pair of chains can be used for attachment.

PART 3 - EXECUTION

3.01 PREPARATION

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

B. Prepare surfaces in accordance with Division 09 Section "Painting" for stencil painting.

3.02 INSTALLATION

A. Plastic nameplates: install with corrosion-resistant mechanical fasteners, or adhesive.

B. Plastic tags: install with corrosion-resistant chain.

C. Stencil painting: apply in accordance with Division 09 Section "Painting".

D. Plastic pipe markers: install in accordance with manufacturer's instructions.

E. Plastic-tape pipe markers: install completely around pipe in accordance with manufacturer's instructions.

F. Underground plastic pipe markers: install 6 to 8 inches (150 to 200 mm) below finished grade, directly above buried pipe.

G. Equipment tags: Install with corrosion-resistant mechanical fasteners.

3.03 IDENTIFICATION SCHEDULE

A. Equipment: identify air-handling units, pumps, heat-transfer equipment, tanks, boilers, blowers, and water-treatment devices, etc (see mechanical and plumbing schedules) with
equipment tags per Section 2.2H. Small devices, such as VAV boxes and VFD’s, may be identified with plastic tags.

B. Controls: identify control panels and major control components outside of panels with plastic nameplates.

C. Valves: identify valves in main and branch piping with tags.

D. Piping: identify piping, concealed or exposed, with stenciled painting. Tags may be used on small diameter piping. Identify service, flow direction, and pressure. Install in clear view and align with axis of piping. Locate identification not more than 20 feet (6 m) apart 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.

E. Ductwork: identify ductwork with stenciled painting. Identify as to air-handling unit number, and area served. Locate identification at air-handling unit, at each side of penetration of structure or enclosure, and at each obstruction.

3.04 VALVE DATABASE

A. Provide specified valve database.

3.05 STENCILING AND IDENTIFICATION

A. Stencil each piece of new and existing equipment including pumps, fans, tanks, etc., with the equipment tags scheduled on the drawings and per Part 2 above.

1. Stencil each duct leaving the mechanical room indicating fan unit, area(s), direction of flow, or room(s) served.

2. Stencil each duct branch leaving an air shaft at each floor with fan number, and identify it as a supply, exhaust, or return duct, and indicate direction of air flow.

B. Post a framed and typewritten schedule of all stencils, pipe markers, and valve tags, used, with identification, shall be framed and posted in the mechanical equipment room.

C. Identify all pipes with specified markers.

1. Install markers every 10 feet (3 m) on mains, at all branch take-offs and adjacent to valves and cocks.

2. Apply to all exposed pipes, pipes behind removable tile ceiling, pipes in concealed but accessible locations, such as behind access panels and at least once in each room.

3. Install pipe marker using pressure sensitive adhesive in accordance with the manufacturer's directions. The marker shall completely cover the circumference of the pipe and overlap itself.

D. Valve Tags: Provide numbered tags for main valves, branch valves, zone valves, shut-off valves, and balancing valves installed under this Contract, constructed of #18 gauge
1. Valve numbers not required for valves obviously serving equipment such as air handler coils, reheat coil valves, and miscellaneous drains.

2. On the as-built drawings, indicate the location and number of each tagged valve.

3. Provide a computer file database in a form agreeable to the Owner, describing the valve, number, location, type of service normally “open” or “closed”, specific duty of each tagged valve, and manufacturer and model number.

E. Warning Sign at Fume Exhaust Plenums: Place warning sign on each fume exhaust plenum access - “WARNING. HAZARDOUS ATMOSPHERE INSIDE. USE BREATHING APPARATUS” when breaching containment.

F. Place warning signs on all machines driven by electric motors which are controlled by fully automatic starters. See Section 3320, Article 7, Subchapter 7, General Industry Safety Orders, Title 8, California Code of Regulations.

G. Fire dampers and fire smoke dampers: at each fire damper or fire smoke damper access panel, label "FIRE DAMPER" or "FIRE SMOKE DAMPER" in minimum 1 inch (25 mm) high letters. Fire smoke dampers shall be provided with tags to identify each fire smoke dampers with 2 lines as follows: the first line “FSD-NUMBER SEQUENCES-BLDG NUMBER” (e.g. FSD-001-15). The second line “ZONE FIRE ALARM-zone” that activates the damper (e.g. ZONE L1-03). Tags shall be engraved plastic with white letters on red background. Provide chart to Owner for approval.

H. Wherever charts, Shop Drawings, etc. Refer to specific room numbers, use room numbers that will be provided by the Owner rather than the room numbers indicated on the Drawings.

I. Equipment, valves, pipes, and ductwork identification shall comply with the Owner’s tagging and numbering system. Prior to fabrication of tags/identification labels, coordinate with the Owner. Submit tags and identification list for review and approval by the Owner and Owner’s Representative.

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY

A. Related Documents:
   1. Drawings and general provisions of the Subcontract apply to this Section.
   2. Review these documents for coordination with additional requirements and information that apply to work under this Section.

B. Section Includes:
   1. Component check
   2. System balancing
   3. Operating tests and training.

C. Related Sections:
   1. Agreement for Mechanical and Control Design-Build Project
   2. Division 23 Section "Instrumentation and Control Devices for HVAC".
   3. Division 25 Section "Facilities Monitoring and Control System".

1.02 REFERENCES

A. General:
   1. The following documents form part of the Specifications to the extent stated. Where differences exist between codes and standards, the one affording the greatest protection shall apply.
   2. Unless otherwise noted, the referenced standard edition is the current one at the time of commencement of the Work.
   3. Refer to Agreement for Mechanical and Control Design-Build Project Requirements for the list of applicable regulatory requirements.
   4. Refer to Division 23 Section "Common Results for HVAC" for codes and standards, and other general requirements.

B. American National Standards Institute (ANSI)
1. ANSI S12.1 Physical Measurement of Sound

C. Associated Air Balance Council (AABC)
   1. AABC 12173 National Standards for Field Measurements and Instrumentation — Total System Balance

D. Cooling Tower Institute (CTI):

1.03 SUBMITTALS

A. Submit under provisions of Division 23 Section “Common Results for HVAC, Review of Materials and Agreement for Mechanical and Control Design-Build Project Section “General Requirements.”

B. Submit test, adjust and balance (TAB) report.

C. LEED Submittals:
   1. Air Balance Report for Prerequisite EQ 1: Documentation of work performed for ASHRAE 62.1-2004, Section 7.2.2 - "Air Balancing."

   2. TAB Report for Prerequisite EQ 1: Documentation of work performed for ASHRAE/IESNA 90.1-2004, Section 6.7.2.3 - "System Balancing."

D. Balancing Organization: Submit for Owner approval, the name of the balancing organization selected prior to commencing work. Criteria for determining acceptable qualifications will be membership in AABC. Please note that certification by NEBB is specifically NOT acceptable.

E. Testing and Balancing Report: All test forms shall be standard 8-1/2 x 11-inch (A4 size), good-quality paper, bound to form a complete report. All forms shall be computer printed, typewritten, or legibly hand lettered; hand-made forms are not acceptable. Submit draft copies prior to final acceptance of the project. Refer to subpart 3.08 “Balancing Report” for specific requirements.

1.04 QUALITY ASSURANCE

A. Obtain the services of a qualified balancing organization to perform testing, balancing, and component check at no additional cost to the Owner. The balancing agency shall be independent of the air-conditioning installer.

B. Perform checks before testing and balancing.

C. Perform balancing in accordance with AABC 12173.

D. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 7.2.2 - "Air Balancing."
PART 2 - PRODUCTS – NOT USED

PART 3 - EXECUTION

3.01 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems", and this section.

1. Comply with requirements in ASHRAE 62.1-2004, Section 7.2.2 - "Air Balancing."

3.02 PREPARATION

A. Check and report defects or deficiencies that may affect balancing.

1. Provide sufficient time before completion date to complete balancing operations.
2. Provide immediate labor and tools to make corrections without delay.
3. Place heating, ventilating, and air-conditioning systems and equipment into full operation and continue operation for each working day of testing and balancing.
4. Note changes made to the system during construction.
5. Install required test holes complete with removable and replaceable plugs.
6. Make necessary revisions to controls, dampers, fan and pump drives, and consult with equipment manufacturers as required to achieve the specified system’s performance.
7. Provide dampers as shown and where required to obtain final system balance.
8. Provide ladders, scaffolds, tools and labor required to facilitate balancing, including removing ceiling tiles and guards, and adjusting pulleys and belts. Reinstall and adjust all items when balancing is finished.
9. Coordinate balancing operations with controls system installation when setting damper linkages and minimum-outside-air dampers. Readjust dampers and improperly calibrated controls as required, in accordance with Division 25 Section "Building Automation and Control System".
10. Set pressure-regulating and reducing valves to operating conditions.
11. Check and set relief and safety valves to specified requirements.

E. ASHRAE/IESNA 90.1-2004 Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004, Section 6.7.2.3 - "System Balancing."
12. Clean strainers. Check air filters immediately prior to air balancing.

13. Open fire dampers.

14. Change variable-pitch pulleys supplied on 20 hp motors and larger, to fixed pulleys after the air balance is completed. Provide such pulleys.

B. Install at each piece of mechanical equipment a “Data Register” showing significant operating temperatures, pressures, amperes, voltage, brake power. Enclose the “Data Register” in a plastic holder securely attached to the equipment, or to an adjacent wall.

3.03 COMPONENT CHECK PRIOR TO BALANCING

A. Check all components such as fans, pumps, boilers, chillers, unitary equipment, and like items, prior to system balancing. [Notify the Owner 24 hours in advance to secure Owner Representative to witness the checks.]

B. Check all equipment according to the manufacturer’s instructions and the following checklist:

1. Pre-Startup Inspection:
   a. Verify proper equipment mounting and setting.
   b. Verify that control, interlock, and power wiring is complete.
   c. Verify alignment of motors and drives.
   d. Verify proper piping connections and accessories.
   e. Verify that lubrication is completed.

2. First Run Observations:
   a. Verify direction of rotation.
   b. Verify setting of safety controls.
   c. Monitor heat buildup in bearings.
   d. Check motor loads against nameplate.

3. Equipment Check:
   a. Verify proper overload heater sizes.
   b. Verify function of safety and operating controls.
   c. Verify proper operation of equipment.
d. Report on inspection, observation, and checking procedures.

C. Check all subsystems prior to system balancing according to the following checklist, where applicable:

1. Air distribution products installation is completed.
2. Filter installation is completed.
3. Instrumentation installation is completed.
4. Hydronic systems have been cleaned and filled with heat transfer fluid.
5. Refrigeration systems have been leak tested, evacuated, and filled with refrigerant and fresh oil.
6. Equipment check completed.
7. Stuffing boxes and packing glands on pumps and valves have been adjusted.
8. Rotation of electric motor and ratings of overload heaters have been verified.
9. Rotating equipment has been aligned and belt drive tension has been adjusted.
10. Control diagrams and sequences have been corrected to “as-built.”
11. Safety and operating control set-points are as designed and automatic control sequences have been checked.
12. Installation has been cleaned-up and temporary coverings, stickers, and tags removed.
13. Painted finishes have been touched-up where damaged.
14. Equipment and piping identification work has been completed with valve tags, schedules, and piping identification system.
15. Fins on extended-surface heat-transfer coils have been combed out where damaged.
16. One set of operating and maintenance manuals has been prepared especially for use by testing and balancing technicians.
17. Building operating and maintenance personnel have been instructed in all aspects of system operation and maintenance.
18. Graphic operational data such as start/stop instructions, valve tag schedules, and piping identification schedules have been provided where needed.
19. Water treatment program has been implemented, with initial qualitative testing of fluids in systems and domestic water supply, check of chemical feeder equipment, and instructions to chemical supplier as to results desired.

3.04 AIR-SYSTEM BALANCE PROCEDURE

A. Execute air systems balancing for each air system in accordance with AABC specifications and as described herein.

B. Make tests with supply, return and exhaust systems operating and doors and windows closed, or in their normal operation condition.

C. Test and adjust blower speed to design requirements.

D. Test and record motor full-load amps.

E. Traverse main supply-air ducts, using a pitot tube and manometer. Calibrate the manometer to read two significant figures in velocity pressure ranges. Take a minimum of 16 readings per traverse to measure the total air quantity supplied by the fan, and to verify air distribution per zone. A main duct is defined as any of the following:

1. A duct serving 5 or more outlets
2. A duct serving 3 or more branch ducts
3. A duct serving a heating coil
4. A zone duct from a terminal variable-air-volume (VAV) box
5. A duct emanating from a fan discharge or plenum, and terminating at one or more outlets

F. Obtain data in support of supply-fan air delivery by the following four methods. For return and exhaust fans, methods 1 and 4 alone are sufficient.

1. By summation of the air-quantity readings at outlets.
2. By duct traverses of main supply ducts.
3. By rotating vane traverse across the filter or coil bank.
4. By plotting revolutions per minute and static pressure readings on the fan curve. Air density corrections shall be indicated.

G. Test and record required and measured system static pressures; filter differential, coil differential, and fan total static pressure.

H. Test and adjust systems for design recirculated airflow rates.

I. Test and adjust system for design volume flow rate of outside air (cfm or L/s).
J. Test and record entering-air temperatures.
K. Test and record leaving-air temperatures.
L. Adjust main supply and return ducts to proper design flow rates.
M. Inspect and confirm all fire dampers are open and have adequate access.
N. Adjust zones to proper design, supply and return flow rates.
O. Test and adjust each diffuser, grille and register to within 10% of design requirements.
P. Identify each diffuser, grille and register as to location and area.
Q. Identify and list size, type and manufacturer of diffusers, grilles, registers and testing equipment. Use manufacturer's rating on equipment to make required calculations.
R. In readings and tests of diffusers, grilles and registers, include required velocity and test velocity (fpm or m/s) and required flow rate (cfm or L/s). Test after adjustment.
S. Control manufacturer shall set adjustments of automatically operated dampers to operate as indicated in cooperation with balancing firms.
T. Adjust diffusers, grilles and registers to minimize drafts and to prevent “short circuiting” between supply and return outlets.
U. Use volume control devices to regulate air quantities only to extent that adjustments do not create objectionable air motion or sound levels. Effect volume control by duct internal devices such as dampers and splitters. Remove air slots on return air troffers to achieve adequate relief to ceiling space.
V. Vary total system air flow rates by adjustment of fan speeds. Vary branch air quantities by damper regulation.
W. Record installed fan drive assemblies; fan sheaves, motor sheaves and belts.
X. Record each installed motor manufacturer.
Y. The final balanced condition of each area shall include testing and adjusting of pressure conditions. Test and record building pressurization levels in variable volume systems through full range of fan delivery rates, under both heating and cooling conditions for multi-story building test pressure conditions at ground, intermediate and upper levels. Front doors, exits and elevator shafts should be checked for air flow so that exterior conditions do not cause excessive or abnormal pressure conditions. Document abnormal building leakage conditions noted.

3.05 HYDRONIC-SYSTEMS BALANCE PROCEDURE

A. System Preparation (Step 1): Prepare the hydronic system for balancing in the following manner:
1. Open valves to full position including coil-stop valves. Close bypass valves and return-line balancing cocks.

2. Examine water in system to determine if it has been treated and is clean.

3. Check pump rotation.

4. Check expansion tanks to ensure that they are not air bound and that the system is full of water.

5. Check air vents at high points of water systems to ensure that they are installed properly and are operating freely. Make certain air is removed from circulating system.

6. Set temperature controls so that coils are calling for full flow. This should close all automatic bypass valves.

7. Check operation of automatic bypass valves.

8. Check and set operating temperature of chiller at design requirements.

9. Execute air balance before water balance is initiated.

B. Testing and Balancing Procedure (Step 2):

1. Check operation of variable speed pump and record pump data at varying percentages of full flow.

2. Set pumps to deliver approximately 10% excess flow volume if possible.

3. Adjust flow through chiller, heat exchanger, and boiler units.

4. Check and record leaving-water and return-water temperatures, and pressure drop through chiller and boiler units. Reset to design temperatures.

5. Check and record water temperature at inlet side of coils. Note rise or drop of temperatures from source.

6. Position and mark automatic valves, hand valves, and balancing cocks for design flow through coils, connectors and all other items in system requiring circulation of chilled water and hot water.

7. For venturi type, pitot tube or other flow-measuring devices, record the pipe size, manufacturer and size of device, and the direct reading of the differential pressure and calculated final flow.

8. Upon completion of flow readings and coil adjustments, mark settings and record data.

9. Ensure bypass valves are tightly closed.
C. Testing and Balancing Procedure (Step 3):

1. After making adjustments to coils, recheck settings at pumps. Readjust if required.

2. Install pressure gauges on each coil, then read pressure drop through coil, and set flow rate on call for full flow through coil. Set pressure drop across bypass valve to match coil full-flow pressure drop.

3. Balance flow through equipment and coils by means of pressure drop. Obtain curves from the equipment manufacturers indicating the relationship between flow and pressure drop through the coils and equipment. Take readings on calibrated test gauges.

4. Upon completion of the water balance, reconcile the total heat transfer through coils by recording the entering and leaving water temperatures, and the entering and leaving air dry-bulb and wet-bulb temperatures.

5. Upon completion of balancing, adjust differential bypasses for the same pressure drop on full bypass as on full flow.

3.06 SOUND-LEVEL TESTING

A. When specifications or equipment schedules set maximum sound power levels for various items and require a sound test, test the specified equipment to verify that the installed equipment does not produce sound in excess of those levels.

B. Take sound readings in dBA in accordance with ANSI S12.1 to determine equipment sound power levels to confirm compliance.

3.07 OPERATING TEST

A. After final adjustments and calibration, component performance check and system balancing have been completed, conduct a continuous 7-hour operating test during normal working hours from 9 a.m. to 4 p.m. in the presence of the Owner Representative.

B. The 7-hour test shall be continuous without any shutdowns. If any interruptions are required for malfunctions or readjustments, repeat the test from the start.

C. The operating test, unless otherwise indicated, shall be conducted to verify the operation of the mechanical system and to demonstrate the performance of the total system.

3.08 24-HOUR TEST

A. Run the system(s) for a total of 24 hours (17 additional hours) after successful completion of the 7-hour operating test.

B. Make a continuous 24-hour recording of test data concurrent with the 7-hour operating test. During the test record the following data hourly:

1. Dry-Bulb and Wet-Bulb Air Temperatures:
a. Entering and leaving each humidifier
b. Entering and leaving each cooling coil
c. Entering and leaving each dryer in the room air circuit
d. Entering and leaving each dryer in the reactivation air circuit
e. Outdoors (calculate and record relative humidity)
f. In the conditioned space (calculate and record relative humidity)

2. Dry-Bulb Air Temperatures:
   a. Entering and leaving each condensing coil
   b. Entering and leaving each gas or oil fired device
   c. Entering and leaving each heating coil

3. Water Temperatures (when the design includes installing measuring hardware):
   a. Entering and leaving each heating coil
   b. Entering and leaving each cooling coil
   c. Entering and leaving each chiller
   d. Entering and leaving each boiler
   e. Entering and leaving each converter
   f. Entering and leaving each condenser
   g. Entering and leaving each condenser

4. Pressures (when the design includes installing measuring hardware):
   a. Refrigerant suction pressure
   b. Refrigerant head pressure

5. Weather Conditions:
   a. Sun
   b. Precipitation
   c. Wind
d. Barometric pressure:

e. Fluid Flows:

1) Through each cooling coil
2) Through each cooling tower
3) Through each chiller
4) Through each hot water boiler

3.09 BALANCING REPORT

A. Include types, serial numbers and dates of calibration of instruments.

B. Record test data on a sepia made from the latest available revised set of mechanical drawings, and submit copies upon completion of balancing.

C. Submit fan and pump curves with operating conditions plotted. Submit grille and diffuser shop drawings and diffusion factors.

D. Index report as follows:

1. Air:
   a. Summary
   b. Procedure
   c. Instrumentation
   d. Drawings
   e. Equipment Summary
   f. Fan Sheets
   g. Fan Curves
   h. Fan Profile Data
   i. Static Data
   j. Air Monitoring Station Data
   k. Traverse Data and Schedule
   l. Terminal Unit Summary
m. Outlet Data Summary and Schematics (per system)

n. Building Pressurization Data

o. Smoke Exhaust Mode Data

p. Stairwell Pressurization Data

q. Smoke Control System Testing (Smoke Control Zone Supply and Exhaust Capabilities)

2. Water:

a. Summary

b. Procedure

c. Instrumentation

d. Pump Data

e. Pump Curves

f. Flow Stations

g. Coils

h. Equipment Data

i. Element Data Summary and Schematics (per system)

3. Sound:

a. Summary

b. Procedure

c. Instrumentation

d. Drawings

e. Profile

f. Scale Readings

4. Fire Damper Verification:

a. Balance

E. Air-Handling Equipment:
1. Installation Data:
   a. Manufacturer
   b. Size
   c. Arrangement, discharge and class
   d. Motor type, power (hp or W), rpm, voltage, phase, cycles and full-load amps
   e. Location and final identification

2. Design Data:
   a. Total airflow rate
   b. Static pressure
   c. Motor power (hp or W), rpm and amps
   d. Fan rpm
   e. Fan power (hp or W)
   f. Inlet and outlet dry-bulb temperatures

3. Recorded Data:
   a. Airflow rate
   b. Static pressure
   c. Fan rpm
   d. Fan power (hp or W)
   e. Motor operating amps
   f. Inlet and outlet dry-bulb temperatures

F. Duct Air Quantities: Maximums and minimums for mains, branches, outside air, and exhausts:
   1. Duct sizes
   2. Number of pressure readings
   3. Sum of velocity measurements
4. Average velocity
5. Duct recorded airflow rate
6. Duct design airflow rates

G. Air Inlets and Outlets:
1. Outlet identification location and designation
2. Manufacturer’s catalogue identification and type
3. Application factors
4. Design and recorded velocities
5. Design and recorded airflow rates
6. Deflector-vane or diffuser-cone settings

H. Building Pressurization Data:
1. Outside air temperatures
2. Outside wind velocity
3. Building pressures plotted with respect to systems
4. Supply-air, return-air and exhaust-airflow rates
5. Locations of pressure measuring points inside and outside building

I. Pumps:
1. Installation Data:
   a. Manufacturer and model
   b. Size
   c. Drive type
   d. Motor type, power (hp or W), rpm, voltage, phase, cycles and full load motor amps
2. Design Data:
   a. Water-flow rate
   b. Pressure
c. Rpm

d. Power (hp or W)

3. Recorded Data:

a. Discharge and suction pressures (full flow and no flow)

b. Operating pressure and total dynamic head

c. Operating water-flow rate (from pump curves if metering not provided, or from variable speed controller)

d. Motor operating amps

J. Expansion Tank Installation Data:

1. Manufacturer, size, and capacity

2. Pressure-reducing-valve setting

3. Pressure-relief-valve setting

K. Heating Equipment:

1. Design Data:

a. Heat-transfer rate

b. Water-flow rate

c. Entering and leaving water temperature

  d. Water pressure drop

2. Recorded Data:

a. Element type and identification (location and designation)

b. Entering and leaving water temperatures

c. Water pressure drop

d. Water-flow rate

L. Air Heating and Cooling Equipment:

1. Design Data:

a. Heat-transfer rate
b. Water pressure-drop across coil

c. Air static-pressure drop

d. Entering and leaving water temperatures

e. Entering and leaving air dry-bulb and wet-bulb temperatures

2. Recorded Data:

a. Element type and identification

b. Entering and leaving air dry-bulb and wet-bulb temperatures

c. Entering and leaving water temperatures

d. Water pressure-drop across coil

e. Water pressure-drop across bypass valve

f. Air static-pressure drop

g. Airflow and water-flow rates

h. Adjusted temperature rise or drop

M. Water Chiller:

1. Installation Data:

a. Manufacturer and model

b. Motor type, kW, rpm, voltage, cycles, phase and full-load amps

c. Water-flow rates

d. Water pressure drops

e. Entering and leaving water temperatures

2. Recorded Data:

a. Water-flow rates

b. Water pressure drops

c. Entering and leaving water temperatures

N. Sound Level Data:
<table>
<thead>
<tr>
<th>Project Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-1129 PAC Boiler Replacement</td>
<td>D-1044 Campus-Wide EMS Upgrades</td>
</tr>
<tr>
<td>C-1130 PAC Chiller Replacement</td>
<td>D-4017 Mechanical Equipment Retrofit</td>
</tr>
<tr>
<td>C-1131 AT Packaged Unit Replacement</td>
<td>P-4022 AHU Replacement</td>
</tr>
</tbody>
</table>

1. Diagram or description of relationship of sound source to measuring instrument

2. Reading at each octave band frequency from 31.5 Hz to 16 kHz and comparison to specified performance

### 3.10 TRAINING

A. Conduct a training session during the operating test. Instruct Owner personnel in the proper operation and maintenance of all controls and operating equipment installed on the job.

B. Operate the equipment from startup through every step, phase or condition the equipment will normally see. Where possible, demonstrate out-of-season operation by false loading or by adjustment of control devices.

C. Fully describe all operations required for the routine and special maintenance of all equipment. Explain such items as cleaning, adjusting and lubrication. Reference operations and maintenance manuals during this session.

D. On occasions where a factory representative must be on hand for the initial startup of a piece of equipment in advance of the operations training session, conduct training for that equipment then.

END OF SECTION
SECTION 23 07 13

DUCTWORK INSULATION

PART 1 - GENERAL

1.01 SUMMARY

A. Related Documents:
   1. Drawings and general provisions of the Subcontract apply to this Section.
   2. Review these documents for coordination with additional requirements and information that apply to work under this Section.

B. Section Includes:
   1. Ductwork insulation.
   2. Insulation jackets.
   3. Insulation vapor barriers.

C. Related Sections:
   1. Agreement for Mechanical and Control Design-Build Project.
   2. Division 23 Section "Ductwork".
   3. Division 23 Section "Identification for HVAC Piping and Equipment".

1.02 REFERENCES

A. General:
   1. The following documents form part of the Specifications to the extent stated. Where differences exist between codes and standards, the one affording the greatest protection shall apply.
   2. Unless otherwise noted, the referenced standard edition is the current one at the time of commencement of the Work.
   3. Refer to Agreement for Mechanical and Control Design-Build Project.
   4. Refer to Division 23 Section "Common Results for HVAC" for codes and standards, vibration and noise, and other general requirements.

B. ASTM International:
1. ASTM C553 Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications
2. ASTM C612 Standard Specification for Mineral Fiber Block and Board Thermal Insulation
C. Code of Federal Regulations 29 CFR 1910.7 Definitions and Requirements for a nationally Recognized Testing Laboratory (NRTL)
D. NFPA - National Fire Protection Association:
   1. NFPA 255 Surface Burning Characteristics of Building Materials
E. Underwriters Laboratory (UL):
   1. UL Building Materials List
   2. UL 723 Surface Burning Characteristics of Building Materials

1.03 INSULATION WORK REQUIREMENTS
A. Insulate HVAC ductwork as follows:
   1. Unless indicated otherwise, new HVAC supply and return air ductwork shall be externally insulated.
      a. Insulate cold room supply and exhaust ducts.
   2. If ducts are internally insulated, they are not externally insulated unless specifically directed.
   3. Transfer and exhaust ducts are internally insulated only if specifically directed.
   4. Install an insulation jacket on externally-insulated HVAC ductwork located outdoors; and indoors except in mechanical rooms and above ceilings.
   5. Insulate outside air intake ducts if located in non-mechanical room indoors space.

1.04 SUBMITTALS
A. Submit under provisions of Division 23 Section "Common Results for HVAC - Review of Materials" and Agreement for Mechanical and Control Design-Build Project.
B. Product Data: Include product description, list of materials, coating sample, and thickness for each service, manufacturer's installation instructions, and locations.
1.05 QUALITY ASSURANCE

A. Applicator: Assure that applicator is a company specializing in ductwork insulation application with 3 years relevant experience.

B. Materials: Listed by a nationally recognized testing laboratory (NRTL) recognized under 29 CFR 1910.7; flame-spread/fuel-contributed/smoke-developed ratings of 25/50/50 in accordance with UL 723.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Knauf, Manville Corporation, Owens-Corning, Casco, Circliner, or equal.

B. Substitutions: Under provisions Agreement for Mechanical and Control Design-Build Project Section "General Requirements - Materials and Equipment".

2.02 MATERIALS

A. Type A: For externally-insulated, round ductwork, insulation shall be 1-1/2" thick flexible glass fiber; ASTM C612; commercial grade; "k" value of 0.29 at 75 deg F (24 deg C); 0.002-inch (0.05 mm) foil-scrim facing.

B. Type B: For externally-insulated, square or rectangular ductwork, insulation shall be rigid glass fiber; ASTMC612, class 1; "k" value of 0.24 at 75 deg F (24 deg C); 0.002-inch (0.05 mm) foil-scrim facing. Provide 3" thick for outdoor installation.

C. Type C: For internally-insulated rectangular ductwork, insulation shall be 1-1/2" thick flexible sheet glass fiber; ASTM C553; "k" value of 0.24 at 75 deg F (24 deg C); 1.5 lb/cu ft. (24 kg/cu. m) minimum density; coated air side for maximum 4,000 ft/min (1219 m/min) air velocity.

D. Type D: Not used.

E. Type E: For internally-insulated round ductwork, insulation shall consist of pre-formed glass fiber sections tightly fit into round ducts and fittings, consisting of ASTM C553 glass fiber, "K" value of 0.24 at 75 deg F (24 deg C); 1.5 lb/cu ft. (24 kg/cu. m) minimum density, and coated on the air side. Provide 1" thick insulation for indoor and 2" thick insulation for outdoor installation.

F. Adhesives: Waterproof, fire-retardant type.

G. Outdoor Jacket: Aluminum, 0.016 inch (0.4 mm) thickness minimum.

H. Vapor Barrier: Non-flammable, fire-resistant, polymeric resin, compatible with the insulation.
I. Lagging Adhesive: Fire resistive in accordance with ASTM E84, NFPA 255, UL 723 or comparable standard by a nationally recognized testing laboratory (NRTL) recognized under 29 CFR 1910.7.

J. Impale Anchors: Galvanized steel, 12 gauge (2.5mm), self-adhesive pad.

K. Tie Wire: Annealed steel, 16 gauge (1.5mm).

L. The use of products with asbestos content is prohibited

PART 3 - EXECUTION

3.01 PREPARATION

A. Install materials after ductwork has been tested and approved.

B. Clean surfaces for adhesives.

C. Install materials in accordance with manufacturer's instructions.

D. Install without sag on underside of ductwork. Use adhesive or mechanical fasteners where necessary to prevent sagging.

E. Seal vapor barrier penetrations by mechanical fasteners with vapor barrier adhesive.

F. Exterior Insulation (Type A or Type B) Application

1. Secure insulation with vapor barrier with adhesive and staples or wires.

2. Stop and point insulation around access doors and damper operators to allow operation without disturbing wrapping.

3. Provide vapor barrier jackets. Cover with specified aluminum jacket with seams located on the bottom side of horizontal piping. Insulate fittings, joints, and valve with insulation of like material and thickness as adjoining pipe, and cover with specified aluminum jacket. Seal jacket joints with vapor barrier adhesive or tape to match jacket.

4. Continue insulation with vapor barrier through penetrations.

G. Rectangular Duct Internal Insulation (Type C) Application

1. Insulate ducts where shown on the Drawings, on the inside.

H. Round Duct Internal Insulation (Type E) Application:

1. As an option to internally lined round duct, provide internally lined rectangular duct with equivalent cross-sectional area and Type C liner.

2. Insulate ducts where shown on the Drawings, on the inside.
3. Coat interior duct surfaces with adhesive prior to installation.

4. Insert liner sections into straight ducts and fittings, achieving a tight fit.

5. Treat factory, shop, and field cut edges with high density spray-on and/or brush-on mastic to lock in fibers and keep the liner from tearing.

6. Repair damaged liner prior to installing ductwork.

7. All adhesive and insulation material shall be fire-retardant and U.L. listed.

8. Submit duct sample of liner, its attachment, and edge treatment.

I. Fire Rated Duct Wrap (Type F) Application:

J. Install fire-rated duct wrap in accordance with the manufacturer's directions. Provide number of layers as needed to achieve fire rating. Fire rating shall be as shown on the Drawings or as needed to continue rating of duct or pipe penetration of rated wall, floor, etc.

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY

A. Related Documents:

1. Drawings and general provisions of the Subcontract apply to this Section.

2. Review these documents for coordination with additional requirements and information that apply to work under this Section.

B. Section Includes:

1. Equipment Insulation.

2. Covering.

C. Related Sections:

1. Agreement for Mechanical and Control Design-Build Project

2. Division 09 "Painting" for painting insulation covering.

3. Division 23 Section "Identification for HVAC Piping and Equipment".

1.02 REFERENCES

A. General:

1. The following documents form part of the Specifications to the extent stated. Where differences exist between codes and standards, the one affording the greatest protection shall apply.

2. Unless otherwise noted, the referenced standard edition is the current one at the time of commencement of the Work.

3. Refer to Agreement for Mechanical and Control Design-Build Project.

B. ASTM International:


2. ASTM C533 Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation
3. ASTM C552 Standard Specification for Cellular Glass Thermal Insulation
5. ASTM C612 Standard Specification for Mineral Fiber Block and Board Thermal Insulation

C. National Fire Protection Association NFPA255 Surface Burning Characteristics of Building Materials

D. Underwriters Laboratories UL723 Surface Burning Characteristics of Building Materials

1.03 SUBMITTALS
A. Submit under provisions of Divisions 01 Section "General Requirements" and "Special Procedures."
B. Include product description, list of materials and thickness for equipment scheduled

1.04 QUALITY ASSURANCE
A. Applicator: Company specializing in insulation application with at least [3] years relevant experience.
B. Insulation and Covering: Fire Hazard: Provide insulation, jackets, facings adhesives and accessories acceptable to the State Fire Marshal, and meeting the requirements of NFPA 90A. Meet the following hazard classifications stated in accordance with U.L. Test Method of Fire Hazard Classifications of Building Materials, No. 723:
   2. Fuel Contributed: Maximum 50.

1.05 PROJECT CONDITIONS
A. Environmental Requirements:
   1. Maintain ambient temperatures and conditions required by manufacturers of adhesive and insulation.
## PART 2 - PRODUCTS

### 2.01 ACCEPTABLE MANUFACTURERS

A. Johns Manville  
B. Owens Corning.  
C. Certain Teed.  
D. Substitutions: Refer to Section Agreement for Mechanical and Control Design-Build Project Section "General Requirements, Paragraph 1.9.D.

### 2.02 INSULATION

A. Type A: Flexible mineral-fiber blanket; ASTMC553; 'k' value of 0.24 at 75°F; lb/cu. ft. density.  
B. Type B: Rigid mineral-fiber board; ASTMC612; 'k' value of 0.24 at 75°F; 6.0 lb/cuft density.  
C. Type C: Cellular glass; ASTMC552; 'k' value of 0.35 at 75°F, 8.0-lb/cuft density.  
D. Type D: Not used.  
E. Type E: Flexible elastomeric cellular; ASTM C534; Type II, 'k' value of 0.25 at 75°. Provide manufacturer furnished UV resistance paint for outdoor installation.

### 2.03 ACCESSORIES

A. Bedding Compounds: Nonshrinking, permanently flexible, compatible with insulation.  
B. Vapor-Barrier Coating: Nonflammable, fire resistant, polymeric resin, compatible with insulation.  
D. Wire Mesh: Corrosion-resistant metal; hexagonal pattern.

### 2.04 ADHESIVES

A. Cellular-Glass, Phenolic, Polyisocyanurate, and Polystyrene Adhesive: Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300 deg F  
   1. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).  
B. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.
1. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

1. For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).


1. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

E. PVC Jacket Adhesive: Compatible with PVC jacket.

1. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

F. Outdoor Insulation Jacket:

1. 0.016” Aluminum with stucco embossed pattern and stainless steel straps.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install materials in accordance with manufacturer's instructions.

B. Do not insulate factory-insulated equipment.

C. Apply insulation as close as possible to equipment by grooving, scoring, and beveling insulation, if necessary. Secure insulation to equipment with studs, pins, clips, adhesive, wires, or bands.

D. Fill joints, cracks, seams, and depressions with bedding compound to form smooth surface. On cold equipment, use vapor-barrier cement.

E. For applying insulating cement, cover insulation with metal mesh and finish with heavy coat of insulating cement.

F. Do not insulate over nameplate or ASME stamps. Bevel and seal insulation around such.

G. When equipment with insulation requires periodical opening for maintenance, repair, or cleaning, install insulation in such a manner that it can be easily removed and replaced without damage.

H. Provide specified jackets over insulation.
### 3.02 SCHEDULE

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<tr>
<th>EQUIPMENT</th>
<th>INSULATION TYPE</th>
<th>THICKNESS</th>
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<tr>
<td>Heating Hot Water Pump</td>
<td>B</td>
<td>1.5</td>
</tr>
<tr>
<td>Expansion Tank</td>
<td>B</td>
<td>1.5</td>
</tr>
<tr>
<td>Air Separators</td>
<td>B</td>
<td>1.5</td>
</tr>
<tr>
<td>Chiller Cold Surfaces (Not Factory Insulated)</td>
<td>E</td>
<td>2.0</td>
</tr>
<tr>
<td>Chilled Water Pump Bodies</td>
<td>E</td>
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</tbody>
</table>

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY

A. Related Documents: Drawings and general provisions of the Subcontract apply to this Section.

1. Review these documents for coordination with additional requirements and information that apply to work under this Section.

B. Section Includes:

1. Piping insulation.
2. Jackets and accessories.

C. Related Sections:

1. Agreement for Mechanical and Control Design-Build Project
2. Division 09 Section "Painting" for painting insulation jacket".
3. Division 23 Section "Identification for HVAC Piping and Equipment".

1.02 REFERENCES

A. General:

1. The following documents form part of the Specifications to the extent stated. Where differences exist between codes and standards, the one affording the greatest protection shall apply.

2. Unless otherwise noted, the referenced standard edition is the current one at the time of commencement of the Work.

3. Refer to Agreement for Mechanical and Control Design-Build Project.

4. Refer to Division 23 Section "Common Results for HVAC" for codes and standards, and other general requirements.

B. ASTM International:

1. ASTM-B-209 Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate

3. ASTM C 196 Standard Specification for Expanded or Exfoliated Vermiculite Thermal Insulating Cement


5. ASTM-C-533 Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation


7. ASTM-C-547 Standard Specification for Mineral Fiber Pipe Insulation

8. ASTM-C-552 Standard Specification for Cellular Glass Thermal Insulation


13. ASTM C 450 Standard Practice for Fabrication of Thermal Insulating Fitting Covers for NPS Piping, and Vessel Lagging


15. ASTM B 209 Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate

16. ASTM A666 Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar

C. Code of Federal Regulations 20-CFR-1910.7 Definitions and Requirements for A Nationally Recognized Testing Laboratory (NRTL)


E. Underwriters Laboratories UL-723 Surface Burning Characteristics of Building Materials
1.03 SUBMITTALS
   A. Submit under provisions of Division 23 Section *Common Results for HVAC, Review of Materials and Agreement for Mechanical and Control Design-Build Project.
   B. Subcontractor shall submit the product description, list of materials and thickness for each service, and at each location.

1.04 QUALITY ASSURANCE
   A. Subcontractor shall assure applicator is a company specializing in piping insulation application with at least 3-years relevant experience.
   B. Fire Hazard: Provide insulation, jackets, facings, adhesives and accessories acceptable to the State Fire Marshal, and meeting the requirements of NFPA 90A. Meet the following hazard classifications stated in accordance with U.L. Test Method of Fire Hazard Classifications of Building Materials, No. 723:

   2. Fuel Contributed: Maximum 50.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS
   A. Manville Corporation, Certain-Teed, or Owens Corning Fiberglass.
   B. Armacell (Armaflex Cellucar Insulation) LLC.
   C. No substitutions.

2.02 INSULATION MATERIALS
   A. Mineral-Fiber Insulation: Glass fibers bonded with a thermosetting resin complying with the following:

   1. Preformed Pipe Insulation: Comply with ASTM C 547, Type I, with factory-applied, all-purpose, vapor-retardant jacket.
   2. Blanket Insulation: Comply with ASTM C553, Type II, without facing.
   3. Fire-Resistant Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
      a. For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
4. Vapor-Retarder Mastics: Fire and water-resistant. Comply with MIL-C 19565C, Type II.
   a. For indoor applications, use mastics that have a VOC content of 20 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).


B. Cellular-Glass Insulation: Inorganic, foamed or cellulated glass, annealed, rigid, hermetically sealed cells, incombustible.

1. Preformed Pipe Insulation, without Jacket: Comply with ASTM C 552, Type II, Class I.

2. Preformed Pipe Insulation, with Jacket: Comply with ASTM C 552, Type II, Class 2.

3. Cellular-Glass, Phenolic, Polyisocyanurate, and Polystyrene Adhesive: Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300 deg F.
   a. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. Flexible Elastomeric Cellular Thermal: ASTM C534/534M, Type 1, k = 0.25 at 75 degrees F, flame spread not over 25, smoke developed not over 50, for temperatures from minus 40 degrees F to 200 degrees F. No jacket required.

D. Prefabricated Thermal Insulating Fitting Covers: Comply with ASTM C 450 for dimensions used in performing insulation to cover valves, elbows, tees, and flanges.

2.03 FIELD-APPLIED JACKETS

A. General: ASTM C 921, Type I, unless otherwise indicated.

B. Foil and Paper Jacket: Not acceptable.

C. PVC Jacket: High-impact, ultraviolet-resistant PVC; 20 mils thick; roll stock ready for shop or field cutting and forming.

1. Adhesive: Compatible with PVC jacket, and recommended by insulation material manufacturer.
a. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2. PVC Jacket Color: White

3. PVC Jacket Color: Color-code piping jacket as determined by existing conditions.

4. Not to be used for outdoors.

D. Heavy PVC Fitting Covers: Factory-fabricated fitting covers manufactured from 30-mil (0.75 mm) thick, high-impact, ultraviolet-resistant PVC.

1. Shapes: 45 and 90-degree, short and long-radius elbows, tees, valves, flanges, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories for the disabled.

2. Adhesive: Compatible with PVC jacket, and recommended by insulation material manufacturer.

a. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

3. Not to be used for outdoors.

E. Aluminum Jacket: Aluminum roll stock, ready for shop or field cutting and forming to indicated sizes. Comply with ASTM B 209 (ASTM B 209M), 3003 alloy, H-14 temper.

1. Finish and Thickness: Smooth finish, 0.010 (0.25 mm) inch thick.


3. Elbows: preformed 45 and 90-degree, short and long-radius elbows; same material, finish, and thickness as jacket.

2.04 ACCESSORIES AND ATTACHMENTS

A. Bands: stainless steel ASTM A666, Type 304, 3/4 inch (20 mm) wide; 0.02 inch (0.050 mm) thick.

2.05 VAPOR RETARDANTS

A. Mastics: Use materials compatible with insulation materials, jackets, and substrates; comply with MIL-C-19565C, Type II.

1. For indoor applications, use mastics that have a VOC content of 20 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2.06 REMOVABLE INSULATION BLANKETS

A. Shop fabricated assembly of woven fiberglass cloth inner liner rated for 1,000 deg. F operation, with two layers of 1-inch thick fiberglass and non-asbestos ceramic insulation covered with a waterproof woven fiberglass outer jacket. Seam shall be sewn with high temperature lacing. Assembly shall include stainless steel hooks and wires, velcro belts or similar devices. Assembly shall have an overall R value of 5.4 or better. Plant insulation Co. “Temp-Mat”, S.R. Corp. “valve insulation covers” or equal.

2.07 SEALANTS

A. Joint sealants, PVC and metal jacket flashing sealants: For indoor applications, use sealants that have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation and other conditions affecting performance of insulation application.

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

3.02 PREPARATION

A. Install materials after piping has been tested and approved.

B. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

3.03 GENERAL APPLICATION REQUIREMENTS

A. Apply insulation materials, accessories, and finishes according to the manufacturer's written instructions; with smooth, straight, and even surfaces; and free of voids throughout the length of ducts and fittings.

B. Refer to schedules at the end of this Section for material, form, jacket, and thickness required for each piping system insulation requirements.

C. Use accessories compatible with insulation materials and suitable for the service. Use accessories that do not corrode, soften or otherwise attack insulation or jacket when in either wet or dry state.

D. Apply insulation with longitudinal seams at top and bottom of horizontal pipe runs.

E. Apply multiple layers of insulation with longitudinal and end seams staggered.

F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
G. Seal joints and seams with vapor-retardant mastic on insulation indicated to receive a vapor retardant.

H. Keep insulation materials dry during application and finishing.

I. Apply insulation with tight longitudinal seams and end joints. Bond the seams and joints with adhesive recommended by the insulation material manufacturer.

J. Apply insulation with the least number of joints practical.

K. Apply insulation over fittings, valves, and specialties, with continuous thermal and vapor-retardant integrity, unless otherwise indicated. Refer to special instruction for applying insulation over fittings, valves, and specialties.

L. Hangers and Anchors: Where vapor retardant is indicated, seal penetrations in insulation at hangers, supports, anchors, and other projections with vapor-retardant mastic.

1. Apply insulation continuously through hangers and around anchor attachments.

2. For insulation application where vapor retardants are indicated, extend insulation on anchor legs at least 12 inches (300 mm)es from point of attachment to pipe and taper insulation ends. Seal tapered ends with a compound recommended by the insulation material manufacturer to maintain vapor retardant integrity.

3. Install insert materials and apply insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by the insulation material manufacturer.

4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect the jacket from tear or puncture by the hanger, support, and shield.

M. Insulation Terminations: For insulation where vapor retardants are indicated, taper insulation ends. Seal tapered ends with a compound recommended by the insulation material manufacturer to maintain vapor retardant integrity.

N. Apply adhesives and mastics at the manufacturer's recommended coverage rate.

O. Apply insulation with integral jackets as follows:

1. Pull jacket tight and smooth.

2. Circumferential Joints: Cover with 3 inches (75 mm) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip and spaced 4-inches o.c.

3. Longitudinal Seams: Overlap jacket seams at least 1 1/2 inches (38 mm). Apply insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 4-inches o.c.
4. Exception: Do not staple longitudinal laps on insulation having a vapor retardant.

5. Vapor-retardant mastics: Where vapor retardants are indicated, apply mastic on seams and joints and at ends adjacent to flanges, unions, valves, and fittings.

6. At penetrations in jackets for thermometers and pressure gauges, fill and seal voids with vapor-retardant mastic.

P. Roof Penetrations: Apply insulation for interior applications to a point even with top of roof flashing.

1. Seal penetrations with vapor-retardant mastic.

2. Apply insulation for exterior applications tightly joined to interior insulation ends.

3. Extend metal jacket for exterior insulation occurring outside of roof flashing at least 2-inches below the top of the roof flashing.

4. Seal sheet metal jacket to roof flashing with vapor-retardant mastic.

Q. Exterior Wall Penetrations: For penetration of below-grade exterior walls, terminate insulation flush with mechanical sleeve seal. Seal terminations with vapor-retardant mastic.

R. Interior Wall and Partition Penetrations: Apply insulation continuously through walls and floors.

S. Fire-Rated Wall and Partition Penetrations: Apply insulation continuously through penetrations of fire-rated walls and partitions

1. Firestopping and fire-resistive joint sealers are specified in Division 07 "Penetration Firestopping".

2. Floor Penetrations: Apply insulation continuously through floor assembly.

3. For insulation with vapor retardants, seal insulation with vapor-retardant mastic where floor supports penetrate vapor retardant.

3.04 MINERAL-FIBER INSULATION APPLICATION

A. Apply insulation to straight pipes and tubes as follows;

1. Secure each layer of preformed pipe insulation to pipe with wire, tape, or bands without deforming insulation materials.

2. Where vapor retarders are indicated, seal longitudinal seams and end joints with vapor-retarder mastic. Apply vapor retarder to ends of insulation at intervals of 15 to 20-feet (4.5 to 6 m) to form a vapor retarder between pipe insulation segments.
3. For insulation with factory-applied jackets, secure laps with outward clinches staples at 6 inches o.c.

4. For insulation with factory-applied jackets with vapor retarders, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by the insulation material manufacturer and seal with vapor-retarder mastic.

B. Apply Insulation to flanges as follows:

1. Apply preformed pipe insulation to outer diameter of pipe flange.

2. Make width of insulation segment the same as overall width of the flange and bolts, plus twice the thickness of the pipe insulation.

3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.

4. Apply canvas jacket material with manufacturer's recommended adhesive, overlapping seams at least 1 inch (25 mm), and seal joints with vapor-retarder mastic.

C. Apply insulation to fittings and elbows as follows:

1. Apply premolded insulation sections of the same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.

2. When premolded insulation elbows and fittings are not available, apply mitered sections of pipe insulation, or glass-fiber blanket insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire, tape, or bands.

3. Cover fittings with heavy PVC covers. Overlap PVC covers on pipe insulation jackets at least 1 inch (25 mm) at each end. Secure fitting covers with manufacturer's attachments and accessories. Seal seams with tape and vapor-retarder mastic.

D. Apply insulation to valves and specialties as follows:

1. Apply premolded insulation sections of the same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.

2. When premolded insulation sections are not available, apply glass-fiber blanket insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation. For check valves, arrange insulation for access to strainer basket without disturbing insulation.

3. Apply insulation to flanges as specified for flange insulation application.
4. Use preformed heavy PVC fitting covers for valve sizes where available. Secure fitting covers with manufacturer’s attachments and accessories. Seal seams with tape and vapor-retarder mastic.

5. For larger sizes where PVC fitting covers are not available, seal insulation with canvas jacket and sealing compound recommended by the insulation material manufacturer.

3.05 CELLULAR-GLASS INSULATION APPLICATION

A. Apply insulation to straight pipes and tubes as follows:

1. Secure each layer of insulation to pipe with bands without deforming insulation.

2. Where vapor retarders are indicated, seal longitudinal seams and end joints with vapor-retarder mastic.

3. For insulation with factory-applied jackets, secure laps with outward clinched staples at 6-inches o.c.

4. For insulation with factory-applied jackets with vapor retarders, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by the insulation material manufacturer and seal with vapor-retarder mastic.

B. Apply insulation to flanges as follows:

1. Apply preformed pipe insulation to outer diameter of pipe flange.

2. Make width of insulation segment the same as overall width of the flange and bolts, plus twice the thickness of the pipe insulation.

3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of cellular-glass block insulation of the same thickness as pipe insulation.

4. Apply insulation to fittings and elbows as follows:

5. Apply premolded insulation sections of the same material as straight segments of pipe insulation when available. Secure according to manufacturer’s written instruction.

6. When premolded sections of insulation are not available, apply mitered sections of cellular-glass insulation. Secure insulation materials with bands.

7. Cover fittings with heavy PVC fitting covers. Overlap PVC covers on pipe insulation jackets as least 1 inch (25 mm) at each end. Secure fitting covers with manufacturer’s attachments and accessories. Seal seams with tape and vapor-retarder mastic.

C. Apply insulation to valves and specialties as follows:
1. Apply premolded segments of cellular-glass insulation or glass-fiber blanket insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation. For check valves, arrange insulation for access to strainer basket without disturbing insulation.

2. Apply insulation to flanges as specified for flange insulation application.


4. For larger sizes where PVC fitting covers are not available, seal insulation with canvas jacket and sealing compound recommended by the insulation material manufacturer.

3.06 PREFORMED ELASTOMERIC CELLULAR THERMAL INSULATION APPLICATION

A. Apply insulation to straight pipes and tubes as follows:

   1. Install pipe insulation by slitting tubular sections and applying onto pipes. Seams and butt joints shall be adhered and sealed using Armaflex 520 adhesive

   2. All edges shall be clean-cut. Rough or jagged edges shall not be permitted.

B. Apply insulation to valves, flanges and fittings as follows:

   1. Insulate with the same insulation thickness as the adjacent piping. Seams and butt joints shall be adhered and sealed with Armaflex 520 adhesive.

   2. All edges shall be clean-cut. Rough or jagged edges shall not be permitted.

C. Outdoor insulation shall be protected as follows:

   1. Furnish aluminum jackets.

   2. All jackets shall have the seams located on the bottom of the pipes.

3.07 FIELD-APPLIED JACKET APPLICATION

A. Apply PVC jacket where indicated, with 1 inch (25 mm) overlap at longitudinal seams and end joints. Seal with manufacturer's recommended adhesive.

B. Apply metal jacket where indicated, with 2-inch (50 mm) overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel band 12 inches (300 mm)es o.c. and at end joints.

C. Insulation and jacket for cold pipes shall include wicks to direct possible condensation to outside the jacket. The product shall be Knauf PermaWick or equal.
D. Indoor, Concealed Applications: Insulated pipes conveying fluids above ambient temperature shall have standard jackets, with or without vapor barrier, factory-applied or field-applied. Insulate fittings, joints and valves with insulation of like material and thickness as adjoining pipe, and finish with glass cloth and adhesive. PVC jackets shall be used for pipes 10 feet or less above the finish floor.

E. Indoor, Exposed Applications: For pipe exposed in mechanical equipment rooms or in finished spaces, insulate as for concealed applications. Finish with canvas jacket; size for finish painting. PVC jackets shall be used for pipes 10 feet or less above the finish floor.

F. Exterior Applications: Provide vapor-barrier jackets. Cover with aluminum jackets with seams located on bottom side of horizontal piping. Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe, and cover with aluminum jackets.

3.08 FINISHES

A. Paint insulation as specified in Division 09 Section "Painting".

B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

3.09 PIPING SYSTEM APPLICATIONS

A. Insulation materials and thicknesses are specified in schedules at the end of this Section.

B. Items Not Insulated: Unless otherwise indicated, do not apply insulation to the following systems, materials, and equipment.

1. Flexible connectors.

2. Vibration control devices.

3. Fire-suppression piping.

4. Drainage piping located in crawl spaces, unless otherwise indicated.

5. Below-grade piping, unless otherwise indicated.

6. Chrome-plated pipes and fittings, unless potential for personal injury.

7. Air chambers, unions, strainers, check valves, plug valves, and flow regulators.

3.10 INSULATION APPLICATION SCHEDULE, GENERAL.

A. Refer to insulation application schedules for required insulation materials, vapor retarders, and field-applied jackets.

B. Application schedules identify piping system and indicate pipe size ranges and material, thickness, and jacket requirements.
3.11 INTERIOR INSULATION APPLICATION SCHEDULE

A. Service: Domestic and Industrial hot water. 203.2 mm
   1. Operating Temperature: 60 to 140 deg F (15.6 to 60 deg C).
   2. Insulation Material: Mineral-fiber
   3. Insulation Thickness: Apply the following insulation thicknesses:
      a. Copper Pipe, Up to 2 inches (50.8 mm): 1 inch (25 mm) Insulation
   4. Field-Applied Jacket: PVC
   5. Vapor Retarder Required: Yes

B. Service: Chilled-water supply and return.
   1. Operating Temperature: 35 to 75 deg F (2 to 24 deg C).
   2. Insulation Material: Mineral-fiber
   3. Insulation Thickness: Apply the following insulation thicknesses:
      a. Steel Pipe, All sizes: 1 inch (25 mm) Insulation
      b. Copper All sizes: 1 inch (25 mm) Insulation
   4. Field-Applied Jacket: PVC
   5. Vapor Retarder Required: Yes

C. Service: Heating hot-water supply and return.
   1. Operating Temperature: 100 to 200 deg F (38 to 93 deg C).
   2. Insulation Material: Mineral-fiber
   3. Insulation Thickness: Apply the following insulation thicknesses:
      a. Steel Pipe, Up to 2 inches (50.8 mm): 1 inch (25 mm) Insulation
      b. Copper Pipe, Up to 2 inches (50.8 mm): 1 inch (25 mm) Insulation
      c. Steel Pipe, 2 1/4 inches (57.2 mm) to 6 inches (152.4 mm): 1 1/2 inch (38 mm) Insulation
HVAC PIPING INSULATION

3.12 EXTERIOR INSULATION APPLICATION SCHEDULE

A. This application schedule is for aboveground insulation outside the building.

B. Service: Domestic, industrial and DI Water.
   1. Operating Temperature: 60 to 140 deg F (15 to 60 deg C).
   2. Insulation Material: Mineral-fiber
   3. Insulation Thickness: Apply the following insulation thicknesses:
      a. Copper pipe, All sizes: 1 inch (25 mm) Insulation
      b. Polypropylene Pipe 1 inch (25 mm) Insulation
   4. Field-Applied Jacket: Aluminum
   5. Vapor Retarder Required: Yes

C. Service: Chilled-water supply and return.
   1. Operating Temperature: 35 to 75 deg F (2 to 24 deg C).
2. Insulation Material: Mineral-fiber

3. Insulation Thickness: Apply the following insulation thicknesses:
   a. Steel pipe, All sizes: 1 1/2 inch (38 mm) Insulation
   b. Copper Pipe, All sizes: 1 1/2 inch (38 mm) Insulation

4. Field-Applied Jacket: Aluminum

5. Vapor Retarder Required: Yes


D. Service: Heating hot-water supply and return.
   1. Operating Temperature: 100 to 220 deg F (38 to 104 deg C)
   2. Insulation Material: Mineral Fiber
   3. Insulation Thickness: Apply the following insulation thicknesses:
      a. Steel Pipe, All sizes: 1 1/2 inch (38 mm) Insulation
      b. Copper Pipe, All sizes: 1 1/2 inch (38 mm) Insulation
   4. Field-Applied Jacket: Aluminum
   5. Vapor Retarder Required: Yes

3.13 REMOVABLE INSULATION JACKETS

A. Use specified removable insulation blankets over temperature control valves, heating hot water isolation valves (4" and larger) and all other high temperature equipment/devices that require frequent service/access.

3.14 ALTERNATE INSULATION APPLICATION

A. Preformed elastomeric cellular insulation may be used as an alternative to the materials in Sections 3.11 and 3.12, for cold water only.

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY

A. The Owner will retain the service of a commissioning agent to act as a commissioning authority, which will coordinate the commissioning process and prepare the pre-commissioning check list (installation verification) and functional performance test. The Design Builder shall perform the commissioning work as specified. This section includes the general commissioning requirements.

B. Related Documents:

1. Drawings and general provisions of the Subcontract apply to this Section.
2. Review these documents for coordination with additional requirements and information that apply to work under this Section.

C. Section Includes:

1. General requirements that apply to implementation of commissioning of HVAC systems, assemblies and components.

D. Related Sections:

1. Agreement for Mechanical and Control Design-Build Project
2. Division 22 Plumbing Sections
3. Division 23 HVAC Sections.

1.02 REFERENCED STANDARDS

A. General:

1. The following documents form part of the Specifications to the extent stated. Where differences exist between codes and standards, the one affording the greatest protection shall apply.

2. Unless otherwise noted, the referenced standard edition is the current one at the time of commencement of the Work.

3. Refer to Agreement for Mechanical and Control Design-Build Project.
4. Refer to Division 23 Section "Common Results for HVAC" for codes and standards, and other general requirements.

1.03 DESCRIPTION

A. The purpose of commission is to ensure the Owner that work has been completed as specified and that systems are functioning in the manner as described in Division 23 Section "Common Results for HVAC" and specified system operating criteria. It will assist operating staff training and familiarization with new systems. It will serve as a tool to reduce post-occupancy critical systems operational difficulty or failure. It will, also, be used to develop test protocol and record the associated test data in an effort to advance the building systems from a state of substantial completion to a full dynamic operation.

B. Commission will commence after preliminary punch list items are completed by Subcontractors.

C. The steps associated with commissioning are outlined below:

1. Step One - Installation Verification

D. Operational staff training is essential to the commission process and will run concurrently with steps one through three.

E. The Commissioning Team will include representatives of the Owner, Construction and Installing Subcontractors, Test and Balance Subcontractor, FMCS Subcontractor and Construction Subcontractor’s Commissioning Agent. Equipment manufacturer’s representatives will be present for start-up as specified in the equipment specification sections and for equipment training.

1.04 SYSTEMS TO BE COMMISSIONED

A. Commissioning will be performed on the following systems:

1. Facility Monitoring and Control System (FMCS)
2. Central Supply, Return and Exhaust Air Systems
3. Chilled Water System
4. Heating Hot Water System

1.05 SUBMITTALS

A. Submit under provisions of Division 23 Section "Common Results for HVAC - Review of Materials" and Agreement for Mechanical and Control Design-Build Project.

B. Commissioning Work Plan.
PART 2 - PRODUCTS

2.01 COMMISSIONING PLAN

A. The commissioning plan shall outline the organization, scheduling, team members, and documentation pertaining to the overall commissioning process.

2.02 NARRATIVE DESCRIPTIONS

A. A narrative description of the design intents of the systems and their intended modes of sequences of operation.

2.03 FUNCTIONAL PERFORMANCE TESTS (FPT) PROCEDURES

A. The FPT procedures at the minimum shall consist of the following sections:

1. Narrative Description:
   a. This section provides a narrative description of the design intents of the systems and their intended modes of sequences of operation.

2. Testing Prerequisites:
   a. This section contains verification that primary mechanical, electrical, and controls systems that support or interact with the system that the FPT is prepared against are completed, tested and operational.

3. Installation Verification:
   a. This section contains verification that the system installation is completed and is ready for commissioning.

4. Commencement of Functional Performance Testing:
   a. This section records the date and time of the start of system commissioning.

5. System Condition Prior to Staring Performance Testing:
   a. This section records the current set points and parameters of the system at the start of commissioning.

6. Functional Performance Test:
   a. This section shall provide the following:

   1) Sequential steps required to set parameters and conditions required to test component and functions throughout intended ranges of operation.
2) Full range of checks and tests carried out to determine if electric and pneumatic connections, components, subsystems, systems and interfaces between systems function in accordance with the contract documents and design intents.

3) All modes and sequences of control operations, interlocks and conditional control responses and specified responses to abnormal emergency conditions.

7. End of Functional Performance Test:
   a. This section records the date and time of the end of system commissioning.

8. Field Notes:
   a. This section records notes or remarks during system commissioning.

9. List systems modifications, not required by the Contract Documents, but provided by the Subcontractor. List other questions regarding such system modifications.

10. List problems discovered during Commissioning that were corrected.

11. List problems discovered during Commissioning that were not corrected.

12. List recommended party that should take action on these problems.

PART 3 - EXECUTION

3.01 GENERAL

A. The Subcontractors shall be responsible for performing procedures presented in specification and contract drawings as detailed in the Functional Performance Tests (FPT). Members of the designated Commissioning Team shall witness various portions of the commissioning process. Responsibilities for these activities are listed in the following paragraphs. Commissioning Team members shall sign-off on appropriate sections after verifying installation, operation, or documentation. Final sign-off shall be by the Owner and Commissioning Agent.

B. Any test ports, gauges, test equipment, etc., needed to accomplish the functional performance tests shall be provided by Subcontractors.

C. Subcontractors shall provide to the Commissioning Team documentation of calibration of controls. Documentation shall include dates, setpoints, calibration coefficients, control loop verification, and other data required to verify system check-out. Documentation shall be dated and initialed by field engineer or technician performing the work.
3.02 OPERATIONAL STAFF TRAINING

A. System narrative descriptions will be prepared by the Commission Agent and supported by flow diagrams, one line diagrams, and appropriate specification sections for major systems to be commissioned. The Commission Agent will coordinate “system description” meetings with members of facility management and maintenance department groups to review system description documentation. The meetings will provide an overview of major system features, components, and arrangements.

B. The Subcontractor and associated manufacturer’s representatives shall provide required training to operational staff after the system description meetings have occurred. The Subcontractor training sessions shall provide a more detailed analogy of systems operation and maintenance.

3.03 INSTRUMENTATION

A. Instrumentation will be provided by the Subcontractor. Instruments used for measurements shall be accurate. Calibration histories for each instrument shall be available for examination. Calibration and maintenance of instruments shall be in accordance with the requirements of NEBB or AABC Standards.

B. Application of instruments and accuracy of measurements shall be in accordance with NEBB or AABC Standards.

3.04 DOCUMENTATION

A. The installing Subcontractor shall be responsible for collection of pertinent data during system start-up and functional performance testing. The Subcontractor shall submit to the Commissioning Agent documentation of tests performed prior to and after system start-up. Documentation shall also include start-up procedures as approved by Commissioning Team.

B. Documentation is to be typewritten on 8-1/2 by 11 inches (200 by 280 mm) paper and inserted in a 2 inches (50 mm) to 3 inches (75 mm) thick three ring binder. Indicate the project name, number, volume number, and volume title on the end panel of each binder.

C. Provide a title sheet for each volume and list the following:

1. Volume Title and Section Name and Number requiring this submittal.
2. Project name, project number, and address.
3. Subcontractor name, address, and phone number.
4. Name, title, signature, and date of person making the submittal.
5. Name of Owner, a blank line for signature, and the date of person accepting the submittal.
6. Name, address, and phone number of Commission Agent; a blank line for signature; and date of person accepting the submittal.
D. Provide a Table of Contents for multiple submittals. List each submittal and page number. Number each page, centered on the bottom in sequential numerical order. Provide tabs for multiple submittals in a single binder.

3.05 STEP ONE - INSTALLATION VERIFICATION

A. General Commissioning responsibilities:

1. Before system start-up begins, the Commission Team shall conduct a final installation verification audit. The Subcontractor shall be responsible for completion of work including change orders and punch list items to the Owner’s satisfaction. The audit shall include, but not be limited to, checking of:
   
   a. Piping specialties including balance, control, and isolation valves.
   b. Ductwork specialty items including turning devices, balance, fire, smoke, control dampers, and access doors.
   c. Control sensor types and location.
   d. Identification of piping, valves, equipment, controls, etc.
   e. Major equipment, pumps, valves, starters, gauges, thermometers, etc.
   f. Documentation of prestart-up tests performed, including manufacturer’s factory tests.

2. If work is found to be incomplete, incorrect, or non-functional, the Subcontractor shall correct the deficiency before system start-up work proceeds.

3.06 STEP TWO - SYSTEM START-UP

A. General Commissioning Responsibilities:

1. A start-up plan shall be developed and submitted by the installing Subcontractor. Start-up plan to include the following:
   
   a. Flushing and cleaning of pipe.
   b. Filters, strainers, and screens.
   c. Valve/damper positions.
   d. Electrical tests.
   e. Pressure tests.
   f. Safeties.
   g. Chemical treatment.
h. Manufacturer’s tests.

2. The start-up plan will be reviewed and a prestart-up inspection performed by designated members of the Commissioning Team. The installing Subcontractor shall commence with system start-up after approval has been given to start-up plan and the prestart-up inspection is completed. Designated members of the Commissioning Team shall witness system start-up and list system and equipment deficiencies noted during start-up. The Subcontractor shall take corrective action on system deficiencies noted and demonstrate to the Commissioning Team members suitable system operation.

3. Designated systems requiring test and balance work shall have this activity commence after systems have successfully completed start-up. System and equipment deficiencies observed during this activity is to be noted and corrected.

3.07 STEP THREE - FUNCTIONAL PERFORMANCE TESTING

A. General Commissioning Responsibilities:

1. Functional Performance Testing begins after operational testing, adjusting, and balancing of the systems have been completed by the Subcontractors; and the System Description and Hands-on Training sessions have been completed.

2. The objective of the Functional Performance Testing is to advance the building systems from a state of substantial completion to full dynamic operation in accordance with the specified design requirements and design intent.

3. Attaining this object will be accomplished by developing individual systems testing protocols which, when implemented by the Subcontractor, will allow the Commissioning Team to observe, evaluate, identify deficiencies, recommend modifications, tune, and document the systems and systems equipment performance over a range of load and functional levels.

4. Functional Performance tests for the systems to be commissioned are defined in the Commissioning Plan. These tests are intended to be conclusive but may require minor modifications as system operation dictates.

END OF SECTION
PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Pumping Systems.

B. Alignment.

C. Accessories.

1.02 RELATED DOCUMENTS:

A. Section 230500 – Common Results for HVAC.

B. Section 230512 – Motors and Drives

C. Section 230548 – Vibration and Seismic Controls for HVAC System and Equipment

D. Section 232113 – Hydronic Piping

E. Section 250000 – Building Automation and Control System.

F. Section 262913 – Low-Voltage Motor Controls

G. Division 26 - Electrical.

1.03 SUBMITTALS

A. Submit in accordance with Agreement for Mechanical and Control Design-Build Project and Section 230500.

B. For Pumps:

1. Pump data showing impeller diameter and complete pump curves through full operating range.

2. Couplings.

3. Motors.

4. Pump shaft seals.

5. Accessories.
1.04 OPERATION AND MAINTENANCE DATA

A. Submit under provisions of Agreement for Mechanical and Control Design-Build Project and Section 15000.

1. Pumps: Startup, Alignment, Maintenance, and Service Instructions.

2. As-built drawings with pump installations shown.

1.05 CODES, REGULATIONS AND STANDARDS

A. All work shall conform to the latest issue of the following codes, regulations and standards:


2. Underwriters Laboratories Standards.


4. NEMA - National Electrical Manufacturers’ Associations.

5. ETL - Electrical Testing Laboratories.


PART 2 - PRODUCTS

2.01 PUMPS

A. Manufacturers: Bell and Gossett, Aurora, PACO, Armstrong, or equal centrifugal pumps.

B. Materials: Cast iron casing, bronze impeller, replaceable bronze shaft sleeve, alloy steel shaft.

C. Arrangement: End suction, spacer coupling, base mounted, or in-line. Provide drain connection in base, and gauge taps at suction and discharge.

D. Pressure/Temperature Rating: 125 PSI at 250 degrees F unless otherwise noted.

E. Seal: Carbon and tungsten carbide faces and TFE or EPT sealing element.

F. Couplings: Falk, Sier-Bath, or equal, all metal flexible connection.

G. Coupling Guard: 10 gauge steel.

2.02 MOTORS

A. Per Section 230512, Motors and Drives.
2.03 ACCESSORIES

A. Suction Diffusers: Bell & Gossett, Thrush-Amtrol co., Armstrong, TACO, Wheatley, or equal suction diffusers of size suitable for pipe riser and end suction centrifugal pump being used. Provide angle type cast iron body with steel inlet vanes, stainless steel permanent strainer, and a 16 mesh bronze disposable start up strainer. Provide a removable permanent magnet for blowdown and cleaning purposes. Provide vanes with length not less than 2-1/2 times the pump connection diameter. Provide a gauge port and integral adjustable foot capable of carrying the weight of the suction pump riser.

PART 3 - EXECUTION

3.01 PUMPS

A. Where suction diffusers are provided, allow ample room to remove temporary strainer. Include pump mounted studs to improve ease of diffuser installation and removal.

B. Alignment: After all piping connections are made, align the pumps. Set with not more than one half the coupling manufacturer's recommended maximum tolerance for parallel and angular variance in alignment.

C. Grout pump frames to bases.

D. After balancing, remove impellers and trim impeller diameters to achieve required head plus 15 percent reserved capacity, re-install and check balancing. This requirement is waived if the impeller size can be demonstrated to be within these tolerances.

END OF SECTION
SECTION 23 21 13

HYDRONIC PIPING

PART 1 - GENERAL

1.01 SUMMARY

A. Related Documents:
   1. Drawings and general provisions of the Subcontract apply to this Section.
   2. Review these documents for coordination with additional requirements and information that apply to work under this Section.

B. Section Includes:
   1. Hot water piping system.
   2. Chilled water piping system, above and underground.
   3. Tower water piping system.
   4. Treated water piping system, above and underground.
   5. Condensate drain.

C. Related Sections:
   1. Agreement for Mechanical and Control Design-Build Project
   2. Division 23 Section "Expansion Fittings and Loops for HVAC Piping".
   3. Division 23 Section "Hangers and Supports for HVAC Piping and Equipment".
   4. Division 23 Section "Identification for HVAC Piping and Equipment".
   5. Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment".
   6. Division 23 Section "HVAC Piping Insulation".
   7. Division 23 Section "HVAC Equipment Insulation".
   8. Division 23 Section "Hydronic Specialties".

1.02 REFERENCES

A. General:
1. The following documents form part of the Specifications to the extent stated. Where differences exist between codes and standards, the one affording the greatest protection shall apply.

2. Unless otherwise noted, the referenced standard edition is the current one at the time of commencement of the Work.

3. Refer to Agreement for Mechanical and Control Design-Build Project.

4. Refer to Division 23 Section "Common Results for HVAC" for codes and standards, and other general requirements.

B. American National Standards Institute (ANSI):

1. ANSI/ASME B31.9 Piping and Piping Systems
2. ANSI/AWS A5.8 Brazing Filler Metal
3. ANSI B2.1 Pipe Threads (Except Dryseal)
4. ANSI B16.3 Malleable-Iron Threaded Fittings
5. ANSI B16.5 Pipe Flanges and Flanged Fittings
6. ANSI B16.9 Factory-Made Wrought Steel Buttwelding Fittings
7. ANSI B16.11 Steel Socket Welding Fittings
8. ANSI B16.18 Cast Brass Solder Fittings
9. ANSI B16.22 Wrought Copper and Wrought Bronze Solder Joint Fittings
10. ANSI B16.24 Bronze Flanges and Flanged Fittings
11. ANSI B16.28 Wrought Steel Buttwelding Short Radius Elbows and Returns
12. ANSI B36.10 Wrought Steel and Wrought Iron Pipe

C. ASTM International:

1. ASTM A 47 Malleable Iron Castings
2. ASTM A 53 and Seamless Pipe, Steel, Black and Hot Dipped Zinc-Coated, Welded
3. ASTM A 106 Service Seamless Carbon Steel Pipe for High-Temperature
1.03 SUBMITTALS

A. Submit under provisions of Division 23 Section "Common Results for HVAC, Review of Materials" and Agreement for Mechanical and Control Design-Build Project Section "General Requirements."

B. Welder's qualification/certifications and welding procedures.

1.04 QUALITY ASSURANCE

A. Valves: Manufacturer's name and pressure rating shall be marked on the valve body.

B. Welding: The Subcontractor is responsible for the quality of welding done by its organization, and shall conduct the required qualification tests to qualify the welding procedures and welders in accordance with ASME/ANSI -B31.3, ASME/ANSI B31.9.

C. Welders Certification: In accordance with ANSI/AWS D1.1 and AWS/API- 1104. The subcontractor shall provide welder's certificate indicating the welder's qualification for conducting welds on the specific materials provided for the project.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store and protect products under provisions of Agreement for Mechanical and Control Design-Build Project Section "Special Procedures."

B. Deliver and store valves in shipping containers with labeling in place.

PART 2 - PRODUCTS

2.01 MATERIAL SCHEDULE

A. Refer to following subparts for complete material specifications for each pipe class specified below.

4. ASTM A 120 Pipe, Steel, Black and Hot Dipped Zinc-Coated, Welded and Seamless, for Ordinary Uses

5. ASTM A 181 Forgings, Carbon Steel for General Purpose Piping

6. ASTM A 197 Cupola Malleable Iron

7. ASTM A 234 Piping and Fittings of Wrought Carbon Steel and Alloy Steel For Moderate and Elevated Temperatures

8. ASTM B 32 Solder Metal

9. ASTM B 62 Composition Bronze or Ounce Metal Castings

10. ASTM B 88 Seamless Copper Water Tube
### Piping System Material Specification

<table>
<thead>
<tr>
<th>Piping System</th>
<th>Material Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chilled Water Supply &amp; Return</td>
<td></td>
</tr>
<tr>
<td>3 inches (75 mm) or less</td>
<td>Pipe Class C1, Type L with soft solder</td>
</tr>
<tr>
<td>Chilled Water Supply &amp; Return</td>
<td></td>
</tr>
<tr>
<td>4 inches (100 mm) or larger</td>
<td>Pipe Class BS2, (black steel)</td>
</tr>
<tr>
<td>Heating Hot Water Supply &amp; Return</td>
<td></td>
</tr>
<tr>
<td>3 inches (75 mm) or less</td>
<td>Pipe Class C1, Type L with soft solder</td>
</tr>
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<td></td>
</tr>
<tr>
<td>4 inches (100 mm) or larger</td>
<td>Pipe Class BS2 (black steel)</td>
</tr>
</tbody>
</table>

#### 2.02 PIPE CLASS BS2: BLACK STEEL PIPE AND FITTINGS

A. Pipe: Black Steel, welded or seamless wall pipe, schedule 40 ASTM A 120 or A 53, ANSI B36.10. Welded joints.

B. Fittings:


2. Pipe Sizes 2-1/2 Inch or Larger: Butt-welding fittings, schedule 40, ASTM A 234, ANSI B16.9. Short radius elbows (ANSI B16.28) will be allowed on gas piping systems, but long radius elbows are preferred and shall be used on other piping systems.

C. Flanges: Slip-on or weld-neck type, 150 lb (68 Kg), raised face, carbon steel, ASTM A 181, Grade 1, dimensions in accordance with ANSI B16.5.

D. Flange Gaskets: Full faced or flat ring, to suit flange facing, spiral wound Type 304 stainless steel metal gasket with flexible graphite filler, Type 304 stainless steel inner ring, and zinc coated carbon steel centering ring, ASME B16.20. Gasket shall meet minimum Class 300 at 500°F; Flexitallic, style CGI, Flexseal RWI, or equal.

E. Flange Bolting: Studs and washers shall be carbon steel, ASTM A-304, Grade B. Nuts shall be heavy hexagon series alloy steel, ASTM A194, Grade 1 or better. All studs and nuts shall be cadmium or zinc plated for indoor and stainless steel for outdoor or inside outdoor air plenum installation.

F. Welding outlets: Grinnell, Weld-O-Let, or equal, forged welding outlets for butt welding or threaded connection as required. Use only for 2 inches and smaller outlets on 4 inches and larger pipes.

G. Unions:
1. Pipe Sizes 2 Inch or Smaller: 150 lb, screwed, black, malleable iron, ground joint, brass to iron seat.

2. Pipe Sizes 2-1/2 Inch or Larger: Use flanges.

H. Local Connections (2 inches or smaller): Threaded joints using 150 lb (68 Kg), black, banded, threaded, malleable iron fittings may be used for exposed local connections. Fittings shall conform to ANSI B16.3, dimensions, ASTM A 197, materials, ANSI B2.1, threads.


2.03 PIPE CLASS C1: COPPER TUBE AND FITTINGS (TYPE K OR L)

A. Tubing: Copper tubing, hard drawn temper, type K or type L, as specified, ASTM B 88. Soldered joints.


C. Flanges: Socket solder-type joint. 150 lb (68 Kg), plain (flat) face, cast bronze, ASTM B 62. Dimensions shall be in accordance with ANSI B16.24.


E. Solder: 95 percent tin, 4 percent copper, 0.5 percent silver, with non-acid flux. 95-5 tin antimony solder is not allowed. Solder with lead content is not allowed. Use silver brazing alloy, as scheduled. or silver brazing alloy, as specified. All solder joints of piping that convey flammable materials shall be made with brazing alloys having melting points above 1000 deg F (538 deg C), (ANSI B31.2; NFPA 51, 31, 58). Silver brazing alloy shall be ANSI/AWS A5.8, classification BCUP-5 containing 15 percent silver, 80 percent copper, 5 percent phosphorous.

2.04 GROOVED JOINT PIPING SYSTEMS (FOR CHILLED, WATER SYSTEMS ONLY)

A. Grooved joint piping systems may be used as option to welding. If a grooved joint piping system is selected, it must be used exclusively, except in special cases where welding is essential.

B. Grooved Joint Couplings: Victaulic 07 rigid grooved end joint couplings for steel pipe, and 606 rigid grooved end joint coupling for copper pipe, Grinnell or equal. Units shall be clamp-on and secured with two bolts rated up to 750 PSI. Gaskets shall be EPDM rated up 230 deg F (110 deg C) service.

1. Use only for above-grade chilled water, tower water, treated water, and heating hot water.

C. Grooved End Pipe Fittings: Victaulic, Grinnell, Gustin-Bacon, or equal. Allowable items are limited to pipe, radius turns, tees, valves, and strainers. Strap-on tees, etc. are not
allowed. Grooved piping system manufacturers must be ISO 9001 certified. Gaskets must be manufactured under ISO 9001 certification.

D. Grooved system components must be from the same manufacturer.

E. Galvanized outdoors.

2.05 VALVE SCHEDULE

<table>
<thead>
<tr>
<th>Service</th>
<th>Size</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>HHW, CHW, TRW, TW, Make-up water and drain, COND, 200 psig non-shock</td>
<td>3 inches (75 mm) or smaller</td>
<td>VB-1.01 Ball Valve</td>
</tr>
<tr>
<td></td>
<td>VB-6.01 Swing Check</td>
<td></td>
</tr>
<tr>
<td></td>
<td>VB-7.01 Circuit Balancing Valve</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4 inches (200 mm) and larger</td>
<td>VB-2.01 Butterfly Valve</td>
</tr>
<tr>
<td></td>
<td>VB-6.02 Spring Loaded Check</td>
<td></td>
</tr>
<tr>
<td></td>
<td>VB-7.01 Circuit Balancing Valve</td>
<td></td>
</tr>
</tbody>
</table>

2.06 BALL VALVES

A. Type VB-1.01 (through 3 inches): 3-piece construction, threaded bronze body with stainless steel or chrome plated brass ball, Teflon seats and packing, blowout-proof stem, 600 PSI WOG. Full port sizes through 2-1/2 inch and conventional port size for 3 inches. Install increasing and reducing fittings as required. Provide extended stem where required to clear insulation. All valves for the natural gas systems shall be AGA certified and UL listed. Red-White, NIBCO T-595-Y-66 through 2-1/2 inches and NIBCO T-590-V for 3 inches, or equal.

2.07 BUTTERFLY VALVES

A. Type VB-2.01: Iron body, aluminum bronze ASTM B-148 alloy 9-C disc, Type 410 stainless steel stem and steel operating handle. All valves shall have full lug style bodies and extended stem so that handle clears the insulation. Valves shall have seven (7) positions to positively lock the valve disc against turning including a positive stop at “OPEN” and “CLOSED” positions. Butterfly valves for throttling and balancing service shall be complete with throttling handle capable of locking in position from “FULL OPEN” to “FULL CLOSED”, position indicator, marked dial plate, and built-in concealed set screw type memory stop. All valves shall have EPDM seats suitable for 250-degree F (121 deg C) water service. Valve shall close bubble tight against 150 psig, 200 deg F (93 deg C) water. Valves shall be fitted between specified flanges and bolted with specified threaded studs, hex nuts and lock washers. All valves shall have a means of mechanically locking in final fixed position. NIBCO CD-2000, DEMCO Series NE, or equal.

1. Where required, provide electric actuators for air suitable for tight shut-off against 150 PSIG water. Include actuator, linkage, mounting assembly and controls. See Drawings.
2.08 CHECK VALVES

A. Type VB-6.01 (1/4 inches to 3 inches): 125-psig SP/200-psig WOG, swing type, bronze body, renewable bronze disc, screwed ends. Lunkenheimer No. 2144, Jenkins 92A, Stockham No. B-319, or equal.

B. Type VB-6.02 (2 inches to 8 inches): 150-psig, spring-loaded clapper, nonslam operation, wafer-type body of ductile iron, with type 316 stainless steel seat or viton seat seals. Use plastic lined, nickel or chromium plated bodies for LCW service. K & F Machine & Mfg. Co. series CV-3 (DEMCO), Mission DUO-CHEK, or equal.

2.09 AIR VENT VALVES

A. Manual Air Vent: See detail.

B. Use 1/2-inch (13 mm), automatic-type air vent valves only where specifically shown on the drawings; Bailey 241, Armstrong 1-AV, or equal. The automatic valves shall be installed on a short, 3/4-inch minimum, riser with globe valve in riser. A full-sized copper tubing drain line shall be provided from the automatic valve to the nearest floor drain, hooper drain, or to the outside if drain line routing is not shown on the drawings.

2.10 LUBRICATED GAS COCKS

A. Over 2-inch size: Homestead 602, Nordstrom 115, or equal lubricated semi-steel, 150 PSI, flanged (for 2 inches and under, use specified ball valves); AGA certified and UL listed.

2.11 GAUGE COCKS

A. Use specified ball valves.

2.12 PIPE SUPPORT DEVICES

A. Pipe Hangers

1. Provide plastic coated pipe hangers, Superstrut C-710P, Unistrut, Tolco, or equal.

2. Refer to Division 230548

B. All Sizes: Superstrut C-710, Grinnell or equal, adjustable clevis hangers.

C. Use plastic coated hangers at all uninsulated copper piping.

D. Trapeze Supports: 12 gauge channel complete with nuts, pipe clamps, pipe straps, and drive-in end caps. Design trapezes for 10,000 PSI maximum stress, or maximum deflection 1/360th of span, whichever is more stringent. Trapezes may be used only for pipes 3 inches and smaller, except where specifically shown otherwise. Furnish cushion strip on all uninsulated copper piping.
E. **Pipe Supported Tight to Wall, Floor, or Ceiling:** Superstrut A1200, Unistrut P1000, or equal, 12 gauge channel complete with pipe clamps, nuts, bolts, and end caps. Furnish cushion strip on all uninsulated piping. Bolt to wall, floor, or ceiling. Caulk all penetrations (other than fire rated wall) with acoustical sealant. See Division 7 for acoustical sealant.

F. **Riser Clamps:** Superstrut C-720, Grinnell Figure 261, or equal. Provide plastic-coated steel clamps for outdoor installation.

G. **Pipe Shields:** Pipe Shields Inc., Insulshield, or equal, pipe hanger shield with waterproofed calcium silicate insulation encased in a galvanized metal casing completely around the pipe. Provide insulation same thickness as pipe insulation. Provide Models CSX-CW for cold water pipes, CS for hot water pipes 2 inches and under, and CSX for hot water pipes over 2". Use saddles specified hereinbefore for all pipes over 6 inches in size.

H. **Hanger Rods:** See Section 23 0529 - Supports and Anchors.

I. **Miscellaneous Steel, Bolts, Nuts, and Washers:** See Section 23 0529.

J. **Attachments to Structure and Seismic Bracing:** See Section 23 0529.

K. All metal components of supports, channels, clamps, hangers, etc., located outdoors and in wet locations shall be constructed of hot dipped galvanized or stainless steel. All related nuts, bolts, washers, or screws shall be stainless steel.

L. **Pipe lagging for noise control**
   1. Provide as shown on the contract drawings
   2. Pipe wrap to include 1" thick 3pcf glass fiber encased in 1lb/ft2 barium loaded vinyl or 20ga aluminum.

2.13 **ESCUCHTEON PLATES**
   A. Chromium-plated brass plates with set screw to hold securely in place, installed on pipes passing through exposed ceilings, floors, and walls in visible locations

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**PART 3 - EXECUTION**

3.01 **PREPARATION**

A. Six-inch pipes, fittings, and valves may be used in lieu of 5-inch, when 5-inch sizes are not available and only with the approval of the University.

B. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.

C. Remove scale and dirt on inside and outside before assembly.

D. Prepare piping connections to equipment with flanges or unions.
HYDRONIC PIPING

3.02 INSTALLATION

A. Route piping plumb and parallel to building structure and maintain gradient.

B. Install piping to conserve building space, and not interfere with use of space and other work.

C. Group piping whenever practical at common elevations.

D. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment. Refer to Division 23 Section "Expansion Fittings and Loops for HVAC Piping".

E. Provide clearance for installation of insulation, and access to valves and fittings.

F. Provide access where valves and fittings are not exposed.

G. Slope piping and arrange systems to drain at low points. Use eccentric reducers to maintain top of pipe level.

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. Prepare pipe, fittings, supports, and accessories for finish painting. Refer to Division 09 Section "Painting".

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

K. Provide manual air vent at all pipe high points.

L. Provide automatic air vent at top of pipe risers.

3.03 PIPE

A. Pressure piping material, fabrication and support shall comply with ANSI B31, American National Standard Code for Pressure Piping, latest edition, including addenda.

B. Use American Standard pipe threads for IPS threaded work. Use no caulking or packing of any kind. Ream out burrs formed by cutting tools and, before installing, examine each section of pipe to see that it is clean and clear. Pipes shall be free from tool marks. In making up screwed joints, apply specified thread lubricant to male threads only.

C. Slope all pressure piping minimum 1 inch in 40 ft. except where space conditions will not permit this slope. Slope water piping up in the direction of flow to high points and provide manual air vents as indicated and/or as required at all high points. Provide 3/4 inch ball valves and capped hose bibb connections at all low points for system drainage. Use eccentric reducing fittings wherever necessary to provide free drainage or venting of lines.
D. Wherever changes in sizes of piping occur, Use reducing fittings. The use of bushings will not be permitted.

E. Bull head tee connection in either mixing or diverging flow will not be permitted.

F. Indirect Drain Piping: Install drains for all equipment requiring drains, full size of equipment connection, and terminate over floor drain funnel, or floor sink as indicated and/or as directed. Do not terminate on floor near floor drain funnel or floor sink. Slope 1/4 inch per foot down to drain. Provide suitable traps in plenum areas.

G. Welding of Pipe Joints: Conform to the requirements of the American National Standard Code for Pressure Piping, ANSI B31, latest edition, including all addenda. Welding of piping may be made by either the electric-arc or gas-welding process. Use fittings in welded pipe specifically designed for welding. 45 degrees and 90 degrees turns shall be long radius type welded fittings. Make branches from welded mains to welded branches with radius welding tees, except 2 inches and smaller branches on 4 inches and larger mains may be made with specified welding outlets. "Cut-In" or mitered welding tees are specifically prohibited. Make branches from welded pipe to screwed pipe with threaded welded fittings.

H. Qualification of Welders: All welders shall be certified welders. Certification shall be within the last five (5) years. The Design Builder shall provide the University with the names of welders employed in the work, together with certification that each of these welders has passed qualification tests as prescribed by the National Certified Pipe Welding Bureau, or by other reputable testing laboratory or agency.

I. Provide brass nipples or couplings to connect to copper connections, such as at coils, heat exchangers, etc. Dielectric unions are not permitted.

J. Carry all exposed and concealed horizontal lines of pipe on specified hangers properly spaced and set to allow the pipe to adjust for expansion and contraction. Use trapeze hangers for supporting groups of pipes. Piping in parallel shall be evenly spaced and supported.

K. Conceal all piping in furred walls, partitions, above ceilings, and pipe spaces except where specifically noted otherwise. Check all piping runs beforehand with all other trades. Run piping to maintain proper clearance for maintenance and to clear openings in exposed areas. Run piping in strict coordination with piping of other trades, ducts, and equipment, all electrical conduit and equipment, structural and architectural conditions, and work of other trades. Verify all inverts and pitched lines before starting work.

L. Install all (exposed and concealed) piping parallel to or at right angles with building walls and tight to walls, ceilings, or structure wherever possible, unless otherwise shown on the Drawings. Install all exposed overhead piping as high, and as tight to structure, as possible.

M. No valve, piece of equipment, or trim shall support the weight of any pipe. Install all valves, vents, traps, cleanouts, trap primers, and other trim in accessible locations. Where shown on the Drawings, and where required, furnish access doors. All equipment in the ceiling space shall be accessible for service.
N. Install all piping free from traps and air pockets and true to line and grade.

O. Where exposed pipes pass through walls, ceilings or floors, fit in all finished rooms and conspicuous locations with escutcheon plates. Escutcheon plates must be securely held in position allowing enough clearance to care for expansion and shall be of sufficient size to cover the opening around the pipe, or insulation. Provide resilient elastomer vibration isolators or sleeves around pipe at point of penetration to prevent structure-borne noise transmission.

P. All valves, strainers, and fittings on piping systems specified with copper pipe shall be brass or bronze body.

Q. Provide resilient elastomer sleeves between pipe and clamps or other supports to prevent transmission of noise to structure.

R. Wrap waste line and uninsulated water pipe over conference rooms and private offices with acoustical pipe scrap.

3.04 PIPE JOINT CONNECTIONS

A. Threaded Pipe: Use Crane No. JC-40, Rector Seal No. 5, or equal, for general service applications, temperatures from –50 to +400 deg F (–45 deg C to 204 deg C), metal or plastic threads, nontoxic, nonhardening, gas pressures to 2600 psi (18 MPa), liquid pressures to 10,000 psi (69 MPa).

B. Copper Tubing with Solder Joint Fittings: Use silver brazed joints for piping located in or under concrete slab on ground, condensate piping located in underground conduits and manholes, and for attaching "Brazolet" fittings for service.

1. Silver brazing alloy shall comply with ANSI/AWS A5.8, class BCUP-5. Use care in silver brazing to prevent overheating of pipe and fittings. Disassemble solder type valves before silver brazing and keep bodies cool.

2. Make other joints with soft solder per Paragraph 2.04.E.

C. Grooved Joint Coupling Systems:

1. Install only on piping systems allowed.

2. Install in accordance with manufacturer's recommendations.

3. Cut grooves are acceptable, all sizes.

4. Rolled grooves are acceptable for pipe sizes 3 inches (75 mm) and larger.

5. Only standard full flow, long radius fittings and specified couplings are acceptable. Clamp-on, drilled-in tee connections are specifically prohibited.

6. Use specified valves.

7. Indicate extent of welding, if still required.
8. Coordinate insulation and jacketing requirements.

3.05 DIELECTRIC INSULATING FITTINGS

A. Insulating unions or flanges shall be provided at locations described herein unless noted otherwise.

B. A shutoff valve shall be provided locally, upstream of dielectric insulating fittings, so that repairs can be made easily on these fittings.

C. Locations requiring insulating couplings or flanges are as follows:

1. At connection points where copper water lines connect to steel domestic water heater tanks.

2. At points in water lines where ferrous and other dissimilar metallic pipes are connected together.

3. In metallic water and gas service connections into each building within 5 feet of the building wall. Install adjacent to the shutoff valve or cock, and aboveground where possible.

4. Where steel or cast iron pipe in the ground connects to copper or brass piping above the ground, the transition from steel or cast iron pipe to the copper or brass pipe shall be made aboveground in an accessible location.

5. Where copper or brass piping is connected to steel or cast iron piping and the connection is buried in the ground, the connection shall be covered with a protective coal tar tape wrap extending outward at least 5 feet on pipes, from the point of connection. The tape shall be Protecto Wrap No. 200, or equal. A primer, specifically designed for use with the tape, shall be used. The piping shall be thoroughly cleaned before tape or primer is applied.

3.06 VALVE INSTALLATION

A. Piping systems shall be supplied with valves at points shown on the drawings or herein specified, arranged so as to give shut-off and regulating control of piping systems throughout the building.

B. Valves shall be the full size of the line in which they are installed.

C. Valves shall be installed in neat arrangements with accessibility for maintenance. No valve shall be installed with its stem pointing down. Globe valves may be installed with stems horizontal, but the preferred position is vertical. All globe and angle valves shall be installed to close against pressure.

3.07 SEISMIC RESTRAINTS

A. Piping and mechanical equipment, with or without vibration isolation, shall be provided with seismic restraints in accordance with CBC Requirements.
C-1129 PAC Boiler Replacement  D-1044 Campus-Wide EMS Upgrades
C-1130 PAC Chiller Replacement  D-4017 Mechanical Equipment Retrofit
C-1131 AT Packaged Unit Replacement  P-4022 AHU Replacement

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY

A. Related Documents:

1. Drawings and general provisions of the Subcontract apply to this Section.

2. Review these documents for coordination with additional requirements and information that apply to work under this Section.

B. Section Includes:

1. Expansion tanks
2. Air vents
3. Air separators
4. Strainers
5. Pump suction fittings
6. Combination fittings
7. Flow indicators, controls, meters
8. Relief valves
9. Meters and gauges
10. Sensor wells
11. Test ports

C. Related Sections:

1. Agreement for Mechanical and Control Design-Build Project
2. Division 23 Section "Hydronic Piping"
3. Division 23 Section "Testing, and Maintenance of HVAC Systems"
4. Division 23 Section "Vibration And Seismic Controls For HVAC System And Equipment"
1.02 REFERENCES

A. General:

1. The following documents form part of the Specifications to the extent stated. Where differences exist between codes and standards, the one affording the greatest protection shall apply.

2. Unless otherwise noted, the referenced standard edition is the current one at the time of commencement of the Work.

3. Refer to Agreement for Mechanical and Control Design-Build Project.

4. Refer to Division 23 Section "Common Results for HVAC" for codes and standards, and other general requirements.


C. Conform to ANSI/ASME Boilers and Pressure Vessels Code Section 8D for manufacture of tanks.

1.03 SUBMITTALS

A. Submit under provisions of Division 23 Section "Common Results for HVAC, Review of Materials" and Agreement for Mechanical and Control Design-Build Project.

B. Submit Shop Drawings and Product Data for manufactured products and assemblies required for this project.

C. Include component sizes, rough-in requirements, service sizes, and finishes. Include product description, model and dimensions.

D. Submit inspection certificates for pressure vessels from authority having jurisdiction.

E. Submit manufacturer's installation instructions under provisions of Agreement for Mechanical and Control Design-Build Project Section "General Requirements - Submittals."

F. Operation and Maintenance Data:

1. Submit operation and maintenance data under provisions of Agreement for Mechanical and Control Design-Build Project.

2. Include installation instruction, assembly views, lubrication instructions, and replacement parts list.

1.04 QUALITY ASSURANCE

A. Manufacturer: For each product specified, provide components by same manufacturer throughout.
1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and protect products under provisions of Agreement for Mechanical and Control Design-Build Project Section "General Requirements - Material Delivery."

PART 2 - PRODUCTS

2.01 BLADDER TYPE EXPANSION TANKS

A. Expansion Tank: Pressurized bladder type expansion tanks, pre-charged as shown on the Drawings and ASME stamped and certified for working pressure of 175 PSIG at 240 degrees F. Provide charging valve, relief valve connection, and system connection. See Drawings for capacity.

B. Acceptable Manufacturers - Expansion Tanks

1. Wessels, Co.
2. Taco, Inc.
3. Bell and Gossett
4. Substitutions: Comply with Agreement for Mechanical and Control Design-Build Project

2.02 AIR SEPARATORS

A. Dip Tube Fitting: For 125 psig (860 kPa) operating pressure; to prevent free air collected in boiler from rising into system.

B. Air Elimination Valve: Bronze, float operated, for 125 psig (860 kPa) operating pressure.

C. Combination Air Separators/Strainers: Steel, tested and stamped in accordance with Section 8D of ANSI/ASME Code, for 125 psig (860 kPa) operating pressure, with galvanized steel integral strainer with 3/16 inch (5 mm) perforations, tangential inlet and outlet connections, and internal stainless steel air collector tube.

D. Acceptable Manufacturers - Air Separators:

1. Bell and Gossett
2. Taco, Inc.
3. Substitutions: Comply with Agreement for Mechanical and Control Design-Build Project Section "General Requirements."

2.03 STRAINERS

A. Size 2 inch (50 mm) and Under: Screwed brass or iron body for 175 psig (1/200 kPa) working pressure, Y pattern with 1/32 inch (0.8 mm) stainless steel perforated screen.
B. Size 2-1/2 inch (65 mm) to 4 inch (100 mm): Flanged iron body for 175 psig (1/200 kPa) working pressure, Y pattern with 3/64 inch (1.2 mm) stainless steel perforated screen.

C. Size 5 inch (125 mm) and Larger: Flanged iron body for 175 psig (1/200 kPa) working pressure, basket pattern with 1/8 inch (3.2 mm) stainless steel perforated screen.

D. Acceptable Manufacturers – Strainers:

1. Bell and Gossett
2. Taco, Inc.
3. Substitutions: Comply with Agreement for Mechanical and Control Design-Build Project Section "General Requirements."

2.04 COMBINATION PUMP DISCHARGE VALVES

A. Valves: Straight or angle pattern, flanged cast-iron valve body with bolt-on bonnet for 175 psig (1/200 kPa) operating pressure, non-slam check valve with spring-loaded bronze disc and seat, stainless steel stem, and calibrated adjustment permitting flow regulation.

B. Acceptable Manufacturers - Combination Pump Discharge Valves:

1. Bell and Gossett or equal.
2. Substitutions: Comply with Agreement for Mechanical and Control Design-Build Project.

2.05 FLEXIBLE CONNECTORS

A. Metal Flexible Connectors: Flexonics 401M, Hyspan, or equal, consisting of Type 321 stainless steel annular corrugated hose and braid with Type 321 stainless steel union, threaded or flanged end connections as specified for the piping system. Units shall be good for a working pressure of at least 240 PSI at 70 deg. F. Submit a schedule of all flexible connections indicating size, live length, maximum anticipated system movement in all planes and allowable connector movement. Select connectors with allowable movement at least 25 percent greater than maximum system movement in all planes.

B. Metal Flexible Connections for Copper Piping System, 2-1/2” and Less: Flexonics 301, Hyspan, or equal, consisting of bronze annular corrugated hose and braid with bronze union and end connections as specified for the piping system. Units shall be good for a working pressure of at least 210 PSI at 70 deg. F. Submit a schedule of all flexible connections indicating size, live length, maximum anticipated system movement in all planes and allowable movement at least 35% greater than maximum system movement in all planes.

C. Flexible pump connectors for heating hot water system: Garlock Style 204HP, Mason, General Rubber, or equal concentric, spool-type expansion joint, single arch, with a chlorobutyl body and polyester fabric, hypalon coating, continuously bonded wire and rectangular steel ring reinforcing, rated for 190 PSI at 250°F for sizes up to 12”. Provide minimum 3/8” thick galvanized or stainless steel backing ring at each flange joint and...
control rods to limit maximum axial extension and compression. Submit a schedule of all flexible connections indicating size, live length, maximum anticipated system movement in all planes and allowable connector movement. Select connectors with allowable movement at least 25% greater than maximum system movement in all planes. Provide rubber grommet such as Mason HG for control rod penetrations through the flange body to minimize short circuit of vibration transmission from the pumps to the piping system.

2.06 TEST PORTS

A. Pete's Plugs, Sisco Plugs, Trerice No. D3742, Flow Design Inc. Superseal, or equal. Provide brass body with 1/2 inch NPT thread, Nordel seal rated 200 PSI at 275 deg. F., suitable for temperature and pressure readings. Provide test kit consisting of two 0-100 PSI pressure gauges, two gauge adapters, two 36 inch long gauge hoses, two 1-1/2 inch, 0 to 220 deg. F, 2 deg. F graduated thermometers, and a carrying case.

2.07 SENSOR WELLS

A. Sensor Wells: Threaded stainless steel, with separable socket, suitable to hold approved thermometers and temperature sensors.

2.08 FLOW CONTROLS

A. Construction: Brass or bronze body with union on inlet and outlet, temperature and pressure test plug on inlet and outlet.

B. Calibration: Control flow within 5 percent of selected rating, over operating pressure range of 10 times minimum pressure required for control, maximum minimum pressure 3.5 psig.

C. Control Mechanism: Stainless steel or nickel plated brass piston or regulator cup, operating against stainless steel helical or wave formed spring.

D. Accessories: In-line strainer on inlet and ball valve on outlet.

E. Acceptable Manufacturers - Flow Controls:

1. Griswold
2. Flow Design Inc.
3. or equal.
4. Substitutions: Comply with Agreement for Mechanical and Control Design-Build Project Section "General Requirements."

2.09 CIRCUIT BALANCING VALVES

A. Armstrong CBV globe style circuit balancing valve. Valve body shall be threaded bronze for sizes up to 2 inch, and flanged cast iron for larger sizes. Valve shall provide tight shut-off against a working pressure of 200 PSI at 250 deg. F. Flow measuring taps shall provide positive shut-off against system pressure and be suitable for quick connection to
a portable differential pressure meter. Valve shall have a vernier type ring scale with at least four 360 deg. turns between full open and full closed, and a memory stop locking device. Insulate valve with removable formed block insulation. Furnish one portable meter kit, Armstrong CBVM 135/60, with dual pressure gauges, hose connections and same pressure/temperature rating as circuit balancing valve. Furnish two bound copies of full size flow charts. Meter kit, after testing and balancing, shall become property of the District.

B. Acceptable Manufacturer, Circuit Balancing Valves:

1. Armstrong CBV
2. TA
3. Substitution: comply with Agreement for Mechanical and Control Design-Build Project, Section “General Requirements"

2.10 METERS AND GAUGES

A. Pressure Gauges: Ashcroft Type 1379, Weksler AY14-2, Palmer, Trerice, or equal, with stainless steel movement, phosphor bronze tube, die cast aluminum case with threaded ring, bottom connection, specified gauge cock and 4-1/2 inch diameter dial. Range 0-100 PSI unless otherwise noted on Drawings. Provide pressure gauge with stainless steel casings for outdoor installations.

B. Thermometers:

1. Pipe Thermometers: Ashcroft 50EI-60E-040, Weksler Type AF, Palmer, Trerice, or equal, dial thermometers, complete with hermetically sealed aluminum case, 5 inch dished dial, stainless steel stem with stainless steel thread connections. 4 inch stem, and extension well. Thermometers must be capable of rotating the dial 360 deg. and rotating the stem 180 deg. and must have an accuracy of 1 percent at mid-range and 2 percent at scale ends. Range 0 deg. to 150 deg. F. for chilled and condenser water piping and 20-240 deg. F. for heating hot water piping. Provide thermometer with stainless steel casing for outdoor installation.

2.11 RELIEF VALVES

A. Bronze body, teflon seat, stainless steel stem and springs, automatic, direct pressure actuated, capacities ASME certified and labelled.

B. Acceptable Manufacturers - Relief Valves:

1. Kunkle Fig. 20
2. Watts
3. Fisher
4. Substitutions: Comply with Agreement for Mechanical and Control Design-Build Project Section “General Requirements.”
PART 3 - EXECUTION

3.01 INSTALLATION AND APPLICATION

A. Install specialties in accordance with manufacturer’s instructions to permit intended performance.

B. Support tanks inside building from building structure in accordance with manufacturer’s instructions.

C. Where large air quantities can accumulate, provide enlarged air collection standpipes.

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

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

F. Provide air separator on suction side of system circulation pump and connect to expansion tank.

G. Provide valved drain and hose connection on strainer blow down connection.

H. Provide pump suction fitting on suction side of centrifugal pumps. Remove temporary strainers after cleaning systems.

I. Provide combination pump discharge valve on discharge side of pumps, where indicated.

J. Support pump fittings with floor mounted pipe and flange supports.

K. Provide relief valves on pressure tanks, low pressure side of reducing valves, heat exchangers, and expansion tanks.

L. Select system relief valve capacity so that it is greater than make-up pressure reducing valve capacity. Select equipment relief valve capacity to exceed rating of connected equipment.

M. Pipe relief valve outlet to nearest floor drain.

N. Where one line vents several relief valves, make cross sectional area equal to sum of individual vent areas.

O. Install strainers ahead of all control valves.

P. Install bypasses around valves where indicated.

Q. Install flexible connectors in all pipes to vibration isolated equipment, and where shown.

1. Install connectors with zero angular and lateral static deflection when systems are at operating weight, and with manufacturer’s recommended installed length.
Provide rigid pipe supports with elastomer sleeves at both ends of flexible connectors.

R. Install test ports at all coil inlets and outlets, and where shown. Test ports shall be fully accessible.

S. Install sensor wells where shown and where required for work of Section 25 50 00. Install oversize fitting where required to avoid flow restrictions. Install in accessible locations.

T. Install circuit balancing valves at accessible locations where shown and wherever necessary for balancing.

U. Install flow meters in pipe furnished by Section 25 50 00. Install per the manufacturer’s recommendations.

V. Install expansion joints or loop to compensate for pipe thermal expansion. Provide and install additional pipe guides per the manufacturer’s recommendation.

W. Install flow control valve where shown.

3.02 METERS AND GAUGES

A. Install pressure gauges and thermometers for easy reading.

B. Install pressure gauges and thermometers in chilled, tower, treated, and heating hot water piping where indicated.

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY

A. Related Documents:
   1. Drawings and general provisions of the Subcontract apply to this Section.
   2. Review these documents for coordination with additional requirements and information that apply to work under this Section.

B. Section Includes:
   1. Cleaning of piping systems.
   2. Chemical feeder equipment.
   3. Treatment for closed systems.
   4. Treatment for open systems.

C. Related Sections:
   1. Agreement for Mechanical and Control Design-Build Project
   2. Division 23 Section "Hydronic Piping" for water coupon rack, by-pass (pot) feeder.

1.02 REFERENCED STANDARDS

A. General:
   1. The following documents form part of the Specifications to the extent stated. Where differences exist between codes and standards, the one affording the greatest protection shall apply.
   2. Unless otherwise noted, the referenced standard edition is the current one at the time of commencement of the Work.
   3. Refer to Division.
   4. Refer to Division 23 Section "Common Results for HVAC" for codes and standards, and other general requirements.
B. Applicable codes for addition of non-potable chemicals to building mechanical systems, and for delivery to public sewage systems.

1.03 SUBMITTALS

A. Submit under provisions of Division 23 Section "Common Results for HVAC, Review of Materials and Agreement for Mechanical and Control Design-Build Project Requirements.

B. Submit Shop Drawings indicating system schematics, equipment locations, and controls schematics.

C. Submit Product Data under provisions of Agreement for Mechanical and Control Design-Build Project.

D. Submit Product Data indicating chemical treatment materials, chemicals, and equipment.

E. Submit reports indicating start-up of treatment systems is completed and operating properly.

F. Submit reports indicating analysis of system water after cleaning and after treatment.

G. Operation And Maintenance Data:
   1. Submit operation and maintenance data under provisions of Agreement for Mechanical and Control Design-Build Project.
   2. Include data on chemical feed pumps, agitators, and other equipment including spare parts lists, procedures, and treatment programs.
   3. Include step by step instructions on test procedures including target concentrations.

1.04 QUALITY ASSURANCE

A. Manufacturer Qualifications: Manufacturer: Company specializing in manufacturing the products specified in this Section with minimum three years experience. Company shall have local representatives with water analysis laboratories and full time service personnel.

1.05 MAINTENANCE

A. Furnish service and maintenance of treatment systems for one year from Date of Substantial Completion.

B. Provide quarterly technical service visits to perform field inspections and make water analysis on site. Detail findings in writing on proper practices, chemical treating requirements, and corrective actions needed. Submit two copies of field service report after each visit.

C. Provide laboratory and technical assistance services for warranty period.
D. Include two hour training course for operating personnel, instructing them on installation, care, maintenance, testing, and operation of water treatment systems. Arrange course at startup of systems.

E. Provide on site inspections of equipment during scheduled or emergency shutdown to properly evaluate success of water treatment program, and make recommendations in writing based upon these inspections.

F. Maintenance Materials: Provide sufficient chemicals for treatment and testing during warranty period.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Garratt-Callahan Company

B. Aqua Treat Chemicals, Inc.

C. Chem Treat, Inc.

2.02 MATERIALS

A. System Cleaner:
   1. Liquid alkaline compound with emulsifying agents and detergents to remove grease and petroleum products.
   2. Algaecide.

B. Closed System Treatment (Water):
   1. Sequestering agent to reduce deposits and adjust pH.
   2. Corrosion inhibitors.
   3. Conductivity enhancers.

2.03 EQUIPMENT

A. By-pass (Pot) Feeder: Six gallon quick opening cap for working pressure of 175 psig.

PART 3 - EXECUTION

3.01 PREPARATION

A. Systems shall be operational, filled, started, and vented prior to cleaning. Use water meter to record capacity in each system.
B. Place terminal control valves in open position during cleaning.

3.02 CLEANING SEQUENCE

A. Add cleaner to closed systems at concentration as recommended by manufacturer.

B. Hot Water Heating Systems: Apply heat while circulating, slowly raising temperature to 160 degrees F (71 degrees C) and maintain for 12 hours minimum. Remove heat and circulate to 100 degrees F (37.8 degrees C) or less; drain systems as quickly as possible and refill with clean water. Circulate for 6 hours at design temperatures, then drain. Refill with clean water and repeat until system cleaner is removed.

C. Chilled and Treated Water Systems: Circulate for 48 hours, then drain systems as quickly as possible. Refill with clean water, circulate for 24 hours, then drain. Refill with clean water and repeat until system cleaner is removed.

D. Use neutralizer agents on recommendation of system cleaner supplier and approval of Owner.

E. Flush open systems with clean water for one hour minimum. Drain completely and refill.

F. Remove, clean, and replace strainer screens.

G. Inspect, remove sludge, and flush low points with clean water after cleaning process is completed. Include disassembly of components as required.

3.03 INSTALLATION

A. Install in accordance with manufacturer’s instructions.

3.04 CLOSED SYSTEM TREATMENT

A. Provide one bypass feeder on each system. Install isolating and drain valves and necessary piping. Install around globe valve downstream of circulating pumps unless indicated otherwise.

B. Introduce closed system treatment through bypass feeder when required or indicated by test.

C. Provide 3/4 inch (19 mm) water coupon rack around circulating pumps with space for 4 test specimens.

3.05 COOLING TOWER WATER TREATMENT

A. Coordinate with the Owner on the existing chemical treatment used.

B. Clean and recharge system per the chemical treatment vendor recommendations.

END OF SECTION
PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Variable frequency drives (VFD) to service motors as indicated on the drawings.

1.02 STANDARDS AND CODES

A. Institute of Electrical and Electronic Engineers (IEEE)

B. Underwriters Laboratories
   1. UL508C

C. National Electrical Manufacturer’s Association (NEMA)
   1. ICS 7.0, AC Adjustable Speed Drives

D. IEC 16800 Parts 1 and 2

1.03 QUALIFICATIONS

A. VFD’s and options shall be UL listed as a complete assembly. VFD’s that require the customer to supply external fuses for the VFD to be UL listed are not acceptable. The base VFD shall be UL listed for 100 KAIC without the need for input fuses.

B. The VFD manufacturer shall have available a comprehensive, HVAC Drive Computer Based Training (CBT) product. The CBT product shall include detailed, interactive sections covering VFD unpacking, proper mechanical and electrical installation, and programming. The CBT product shall allow the user to provide just-in-time training to new personnel or refresher training for maintenance and repair personnel on the user’s site. The CBT product shall be repeatable, precise and shall include record keeping capability. The CBT product shall record answers to simulations and tests by student ID. The CBT product must be professionally produced and have interactive sections, student tests, and include video clips of proper wiring and installation.

1.04 SUBMITTALS

A. Submit catalog data showing material information to be in conformance with specifications. The intended use of each item shall be indicated.

B. Outline dimensions, conduit entry locations and weight.
C. Customer connection and power wiring diagrams.
D. Complete technical product description, including a complete list of options provided.
E. Compliance to IEEE 519 – harmonic analysis for particular jobsite including total harmonic voltage distortion and total harmonic current distortion (TDD).
   1. Provide calculations specific to this installation, showing total harmonic voltage distortion is less than 5%. Input line filters shall be sized and provided to ensure compliance with IEEE standard 519. All VFD’s shall include a minimum of 5% impedance reactors, no exceptions.
F. Submit statement guaranteeing compatibility of submitted motors with submitted variable frequency drives. Guarantee that the motor will operate properly with the submitted variable frequency drives without objectionable motor noise, heat, or loss of efficiency.
G. Submit product manuals and drawings which include wiring diagrams, dimensions, front view and catalog information indicating complete electrical and mechanical characteristics.

PART 2 - PRODUCTS

2.01 GENERAL

A. Capacity and Performance: Provide necessary calculations for correct sizing of equipment for the specific application. Size equipment based on load served and calculations.
B. Manufacturers: ABB ACH 550 Series, or equal. Only one brand may be provided for the entire project.

2.02 VARIABLE FREQUENCY DRIVES (VFD)

A. The VFD package as specified herein shall be enclosed in a UL Listed Type 1 enclosure or Nema 3R enclosure for exterior installation, completely assembled and tested in an ISO9001 facility. The VFD tolerated voltage window shall allow the VFD to operate from a line of +30% nominal, and -35% nominal voltage as a minimum.
   1. Environmental operating conditions: 0 to 40°C continuous. Altitude 0 to 3300 feet above sea level, less than 95% humidity, non-condensing.
   2. Enclosure shall be UL listed as a plenum rated VFD.
B. All VFD’s shall have the following standard features:
   1. All VFD’s shall have the same customer interface, including digital display, and keypad, regardless of horsepower rating. The keypad shall be removable, capable of remote mounting and allow for uploading and downloading of parameter settings as an aid for start-up of multiple VFD’s.
2. The keypad shall include Hand-Off-Auto selections and manual speed control. The drive shall incorporate “bumpless transfer” of speed reference when switching between “Hand” and “Auto” modes. There shall be fault reset and “Help” buttons on the keypad. The Help button shall include “on-line” assistance for programming and troubleshooting.

3. There shall be a built-in time clock in the VFD keypad. The clock shall have a battery backup with 10 years minimum life span. The clock shall be used to date and time stamp faults and record operating parameters at the time of fault. If the battery fails, the VFD shall automatically revert to hours of operation since initial power up. The clock shall also be programmable to control start/stop functions, constant speeds, PID parameter sets and output relays. The VFD shall have a digital input that allows an override to the time clock (when in the off mode) for a programmable time frame. There shall be four (4) separate, independent timer functions that have both weekday and weekend settings.

4. The VFD shall utilize pre-programmed application macros specifically designed to facilitate start-up. The Application Macros shall provide one command to reprogram all parameters and customer interfaces for a particular application to reduce programming time. The VFD shall have two user macros to allow the end-user to create and save custom settings.

5. The VFD shall have cooling fans that are designed for easy replacement. The fans shall be designed for replacement without requiring removing the VFD from the wall or removal of circuit boards. The VFD cooling fans shall operate only when required. To extend the fan and bearing operating life, operating temperature will be monitored and used to cycle the fans on and off as required.

6. The VFD shall be capable of starting into a coasting load (forward or reverse) up to full speed and accelerate or decelerate to setpoint without safety tripping or component damage (flying start).

7. The VFD shall have the ability to automatically restart after an over-current, over-voltage, under-voltage, or loss of input signal protective trip. The number of restart attempts, trial time, and time between attempts shall be programmable.

8. The overload rating of the drive shall be 110% of its normal duty current rating for 1 minute every 10 minutes, 130% overload for 2 seconds. The minimum FLA rating shall meet or exceed the values in the CEC/UL table 430-150 for 4-pole motors.

9. The VFD shall have an integral 5% impedance line reactors to reduce the harmonics to the power line and to add protection from AC line transients. The 5% impedance may be from dual (positive and negative DC bus) reactors, or 5% AC line reactors. VFD’s with only one DC reactor shall add AC line reactors.

10. The input current rating of the VFD shall be no more than 3% greater than the output current rating. VFD’s with higher input current ratings require the upstream wiring, protection devices and source transformers to be oversized per NEC 430-2.
11. The VFD shall include a coordinated AC transient protection system consisting of 4-120 joule rated MOV’s (phase to phase and phase to ground), a capacitor clamp, and 5% impedance reactors.

12. The VFD shall be capable of sensing a loss of load (broken belt / broken coupling) and signal the loss of load condition. The drive shall be programmable to signal this condition via a keypad warning, relay output and/or over the serial communications bus. Relay outputs shall include programmable time delays that will allow for drive acceleration from zero speed without signaling a false underload condition.

13. If the input reference (4-20mA or 2-10V) is lost, the VFD shall give the user the option of either (1) stopping and displaying a fault, (2) running at a programmable preset speed, (3) hold the VFD speed based on the last good reference received, or (4) cause a warning to be issued, as selected by the user. The drive shall be programmable to signal this condition via a keypad warning, relay output and/or over the serial communication bus.

14. The VFD shall have programmable “Sleep” and “Wake up” functions to allow the drive to be started and stopped from the level of a process feedback signal.

15. All VFDs shall equip with disconnect switch with auxiliary contact.

C. All VFDs to have the following adjustments:

1. Three (3) programmable critical frequency lockout ranges to prevent the VFD from operating the load continuously at an unstable speed.

2. Two (2) PID Setpoint controllers shall be standard in the drive, allowing pressure or flow signals to be connected to the VFD, using the microprocessor in the VFD for the closed loop control. The VFD shall have 250 ma of 24 VDC auxiliary power and be capable of loop powering a transmitter supplied by others. The PID setpoint shall be adjustable from the VFD keypad, analog inputs, or over the communications bus. There shall be two parameter sets for the first PID that allow the sets to be switched via a digital input, serial communications or from the keypad for night setback, summer/winter setpoints, etc. There shall be an independent, second PID loop that can utilize the second analog input and modulate one of the analog outputs to maintain setpoint of an independent process (ie. valves, dampers, etc.). All setpoints, process variables, etc. to be accessible from the serial communication network. The setpoints shall be set in Engineering units and not require a percentage of the transducer input.

3. Two (2) programmable analog inputs shall accept current or voltage signals.

4. Two (2) programmable analog outputs (0-20ma or 4-20 ma). The outputs may be programmed to output proportional to Frequency, Motor Speed, Output Voltage, Output Current, Motor Torque, Motor Power (kW), DC Bus voltage, Active Reference, and other data.

5. Six (6) programmable digital inputs for maximum flexibility in interfacing with external devices, typically programmed as follows:
a. There shall be a run permissive circuit for damper or valve control. Regardless of the source of a run command (keypad, input contact closure, time-clock control, or serial communications) the VFD shall provide a dry contact closure that will signal the damper to open (VFD motor does not operate). When the damper is fully open, a normally open dry contact (end-switch) shall close. The closed end-switch is wired to an VFD digital input and allows VFD motor operation. Two separate safety interlock inputs shall be provided. When either safety is opened, the motor shall be commanded to coast to stop, and the damper shall be commanded to close. The keypad shall display “start enable 1 (or 2) missing”. The safety status shall also be transmitted over the serial communications bus. All digital inputs shall be programmable to initiate upon an application or removal of 24VDC.

6. Three (3) programmable digital Form-C relay outputs. The relays shall include programmable on and off delay times and adjustable hysteresis. Default settings shall be for run, not faulted (fail safe), and run permissive. The relays shall be rated for maximum switching current 8 amps at 24 VDC and 0.4 A at 250 VAC; Maximum voltage 300 VDC and 250 VAC; continuous current rating 2 amps RMS. Outputs shall be true Form C type contacts; open collector outputs are not acceptable.

7. Seven (7) programmable preset speeds.

8. Two independently adjustable accel and decel ramps with 1 – 1800 seconds adjustable time ramps.

9. The VFD shall include a motor flux optimization circuit that will automatically reduce applied motor voltage to the motor to optimize energy consumption and audible motor noise.

10. The VFD shall include a carrier frequency control circuit that reduces the carrier frequency based on actual VFD temperature that allows the highest carrier frequency without derating the VFD or operating at high carrier frequency only at low speeds.

11. The VFD shall include password protection against parameter changes.

D. The Keypad shall include a backlit LCD display. The display shall be in complete English words for programming and fault diagnostics (alpha-numeric codes are not acceptable). The keypad shall utilize the following assistants:

1. Start-up assistants.
2. Parameter assistants
3. Maintenance assistant
4. Troubleshooting assistant
E. All applicable operating values shall be capable of being displayed in engineering (user) units. A minimum of three operating values from the list below shall be capable of being displayed at all times. The display shall be in complete English words (alpha-numeric codes are not acceptable):

1. Output Frequency
2. Motor Speed (RPM, %, or Engineering units)
3. Motor Current
4. Calculated Motor Torque
5. Calculated Motor Power (kW)
6. DC Bus Voltage
7. Output Voltage

F. The VFD shall include a fireman’s override input. Upon receipt of a contact closure from the fireman’s control station, the VFD shall operate at an adjustable preset speed. The mode shall override all other inputs (analog/digital, serial communication, and all keypad commands) and force the motor to run at the adjustable, preset speed. “Override Mode” shall be displayed on the keypad. Upon removal of the override signal, the VFD shall resume normal operation.

G. Serial Communications

1. The VFD shall have an RS-485 port as standard. The standard protocols shall be Modbus, Johnson Controls N2 bus, and Siemens Building Technologies FLN. Optional protocols for LonWorks, BACnet, Profibus, Ethernet, and DeviceNet shall be available. Each individual drive shall have the protocol in the base VFD. The use of third party gateways and multiplexers is not acceptable. All protocols shall be “certified” by the governing authority. Use of non-certified protocols is not allowed.

2. The BACnet connection shall be an RS485, MSTP interface operating at 9.6, 19.2, 38.4, or 76.8 Kbps. The connection shall be tested by the BACnet Testing Labs (BTL) and be BTL Listed. The BACnet interface shall conform to the BACnet standard device type of an Applications Specific Controller (B-ASC). The interface shall support all BIBBs defined by the BACnet standard profile for a B-ASC including, but not limited to:
   a. Data Sharing – Read Property – B.
   b. Data Sharing – Write Property – B.
e. Device Management – Communication Control – B.

3. If additional hardware is required to obtain the BACnet interface, provide one BACnet gateway per drive. Multiple VFDs sharing one gateway shall not be acceptable.

4. Serial communication capabilities shall include, but not be limited to; run-stop control, speed set adjustment, proportional/integral/derivative PID control adjustments, current limit, accel/decel time adjustments, and lock and unlock the keypad. The drive shall have the capability of allowing the DDC to monitor feedback such as process variable feedback, output speed / frequency, current (in amps), % torque, power (kW), kilowatt hours (resettable), operating hours (resettable), and drive temperature. The DDC shall also be capable of monitoring the VFD relay output status, digital input status, and all analog input and analog output values. All diagnostic warning and fault information shall be transmitted over the serial communications bus. Remote VFD fault reset shall be possible. The following additional status indications and settings shall be transmitted over the serial communications bus – keypad “Hand” or “Auto” selected, bypass selected, the ability to change the PID setpoint, and the ability to force the unit to bypass (if bypass is specified). The DDC system shall also be able to monitor if the motor is running in the VFD mode or bypass mode (if bypass is specified) over serial communications. A minimum of 15 field parameters shall be capable of being monitored.

5. The VFD shall allow the DDC to control the drive’s digital and analog outputs via the serial interface. This control shall be independent of any VFD function. For example, the analog outputs may be used for modulating chilled water valves or cooling tower bypass valves. The drive’s digital (relay) outputs may be used to actuate a damper, open a valve or control any other device that requires a maintained contact for operation. In addition, all of the drive’s digital and analog inputs shall be capable of being monitored by the DDC system.

6. The VFD shall include an independent PID loop for customer use. The independent PID loop may be used for cooling tower bypass value control, chilled water value control, etc. Both the VFD control PID loop and the independent PID loop shall continue functioning even if the serial communications connection is lost. The VFD shall keep the last good set-point command and last good DO & AO commands in memory in the event the serial communications connection is lost.

H. EMI / RFI filters. All VFD’s shall include EMI/RFI filters. The onboard filters shall allow the VFD assembly to be CE Marked and the VFD shall meet product standard EN 61800-3 for the First Environment restricted level.

I. All VFD’s through 50HP shall be protected from input and output power miss-wiring. The VFD shall sense this condition and display an alarm on the keypad.

J. VFD located outdoors or the mechanical equipment level shall be completely enclosed in NEMA 3R enclosures. VFDs located in other locations shall be in UL approved type 1 or 12( where indicated) enclosure.
PART 3 - EXECUTION

3.01 INSTALLATION

A. Install the drive in accordance with the recommendations of the VFD manufacturer as outlined in the installation manual.

B. Provide all wiring in accordance with the recommendations of the VFD manufacturer and Division 26 requirements.

3.02 START-UP

A. Certified factory start-up shall be provided for each drive by a factory authorized service center. A certified start-up form shall be filled out for each drive with a copy provided to the District, and a copy kept on file by the manufacturer.

3.03 PRODUCT SUPPORT

A. Factory trained application engineering and service personnel that are thoroughly familiar with the VFD products offered shall be locally available at both the specifying and installation locations. A 24/365 technical support line shall be available on a toll-free line.

B. A computer based training CD shall be provided to the District at the time of project closeout. The training shall include installation, programming and operation of the VFD, bypass and serial communication.

3.04 WARRANTY

A. Warranty shall be 24 months from the date of certified start-up. The warranty shall include all parts, labor, travel time and expenses. There shall be 365/24 support available via a toll free phone number. See Agreement for Mechanical and Control Design-Build Project and Section 260500 for additional requirements.

END OF SECTION
SECTION 23 31 13

METAL DUCTS

PART 1 - GENERAL

1.01 SUMMARY

A. Related Documents:
   1. Drawings and general provisions of the Subcontract apply to this Section.
   2. Review these documents for coordination with additional requirements and information that apply to work under this Section.

B. Section Includes:
   1. Low-pressure ducts.
   2. Medium- and high-pressure ducts.
   3. Plenums.
   4. Sound traps.
   5. Pre-fabricated sheet metal curb.
   6. Duct liner.
   7. Fire rated duct.

C. Related Sections:
   1. Agreement for Mechanical and Control Design-Build Project
   2. Division 09 Section "Painting".
   3. Division 23 Section "Hangers and Supports for HVAC System and Equipment" for sleeves.
   4. Division 23 Section "Vibration and Seismic Controls for HVAC System and Equipment".
   5. Division 23 Section "Duct Insulation".
   6. Division 23 Section "Metal Ducts Fittings".
   7. Division 23 Section "Testing, Adjusting, and Balancing for HVAC".
1.02 REFERENCES

A. General:

1. The following documents form part of the Specifications to the extent stated. Where differences exist between codes and standards, the one affording the greatest protection shall apply.

2. Unless otherwise noted, the referenced standard edition is the current one at the time of commencement of the Work.

3. Refer to Agreement for Mechanical and Control Design-Build Project.

4. Refer to Division 23 Section "Common Results for HVAC" for codes and standards, and other general requirements.


1. 29 CFR 1910.7 Definitions and Requirements for a Nationally Recognized Testing Laboratory (NRTL)

C. American Conference of Governmental Industrial Hygienists (ACGIH):

1. ACGIH Industrial Ventilation

D. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE):

1. ASHRAE Handbook Series Fundamentals: Ch. 2. Duct Design


E. ASTM International:


3. ASTM A653 / A653M: Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process

4. ASTM E-119: Compliance as Intertek ETL Semko test and evaluation number 3114842. This includes compliance with the hose stream test requirements.

F. International Conference of Building Officials (ICBO):

1. ICBO UMC Chapter 11

G. National Fire Protection Association (NFPA):
1. NFPA 90A  Installation of Air Conditioning and Ventilating Systems
2. NFPA 90B  Installation of Warm Air Heating and Air Conditioning Systems

H. Sheet Metal and Air Conditioning Subcontractors National Association (SMACNA):
   1. SMACNA HVAC Duct Construction Standards
   2. SMACNA Round Industrial Duct Construction Standards
   3. SMACNA Rectangular Duct Construction Standards
   4. IAQ Guidelines for Occupied Buildings Under Construction.

I. Underwriters Laboratories Inc. (UL):
   1. UL 181 Factory-Made Air Ducts and Air Connectors
   2. UL File #18284: Report on Ventilation Duct Through Penetration Fire Stop System.

J. ISO:

1.03 DEFINITIONS

A. Medium pressure ductwork includes:
   1. All duct risers enclosed in shafts.
   2. All exhaust ductwork connected to fans with scheduled static pressure exceeding 2” water column.
   3. All supply ductwork upstream of airflow control (or VAV) terminals or reheat coils.
   4. Fume exhaust duct.
   5. Lab exhaust system ductwork up to the exhaust VAV terminals.
   6. Lab exhaust fan discharge duct and stacks.
   7. Other ductwork noted or specified as medium pressure construction.

B. Low pressure ductwork includes:
   1. All galvanized ductwork downstream of air terminals and reheat coils, and ducts not included under medium pressure ductwork above.
2. All galvanized ductwork upstream of room exhaust air terminals.

C. Humidifier Section Ductwork: Type 304 Stainless steel.

D. Fume Exhaust Ductwork: Type 316 stainless steel.

E. Duct pressure classification shall be as specified herein and not as recommended in SMACNA publications.

1.04 PERFORMANCE REQUIREMENTS

A. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.

1.05 SUBMITTALS

A. Submit under provisions of Division 23 Section "Common Results for HVAC, Review of Materials and Agreement for Mechanical and Control Design-Build Project.

B. Ductwork.

C. Single and double walled plenum and ductwork, including pre-fabricated, pre-insulated plenum.

D. Sound traps.

E. Shop Drawings:

1. Duct reinforcement and construction schedules.

2. Duct support and bracing details, including calculations as required per CBC requirements.

3. Detailed duct shop drawings at 1/4" - 1'-0" scale in accordance with Division 23 Section "Common Results for HVAC", of mechanical rooms, riser elevations, and floor plans.


5. Pre-fabricated, pre-insulated plenums. Include calculations stamp & sign by a registered structural engineer.

6. Pre-fabricated sheet metal curb.

F. Written program outlining protection of ductwork from contamination with dirt and procedures for cleaning contaminated ductwork.
1.06 QUALITY ASSURANCE


B. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004, Section 6.4.4 - "HVAC System Construction and Insulation."

PART 2 - PRODUCTS

2.01 DUCTWORK:

A. Sheet Metal for Ducts: G90 galvanized steel sheets with 1.25oz./sq. ft. coating on each side, conforming to ASTM A-525 and A-527, lock-forming grade, of gauges as specified hereinafter, except where another material is specifically indicated. See PART 3 - EXECUTION, and drawings for duct construction requirements.

B. Flexible Ducts: See Division 23 Section "Metal Duct Fittings".

2.02 SINGLE WALL PLENUMS:

A. Machine formed panels, minimum 18 gauge steel with 3" standing seams 16" on center. Construct per SMACNA requirements, six inches w.c. pressure class.

B. General Duty: Galvanized steel.

2.03 PRE-FABRICATED SHEET METAL CURB

A. Insulated roof curb constructed of minimum 14 gage galvanized steel with 1-1/2 inch thick, 3 lb. Density fiberglass insulation and wood nailer.

2.04 DUCT SEALANT

A. For non-fume exhaust duty and galvanized fume exhaust duty: United Duct Sealer, 3M #800, or equal, non-flammable, U.L. labeled.

B. Solvent-Based Joint and Seam Sealant:
   1. For indoor applications, use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   2. VOC: Maximum 395 g/L.

C. Sealant for fume exhaust duct: Use Sika Flex 1A.

2.05 GASKET MATERIAL

A. For non-fume exhaust duty and galvanized fume exhaust duct duty: Tremco 440, Ductmate 440, or equal, minimum 3/16" thick by 1/2" wide.
B. For stainless steel and coated fume exhaust duct duty: Where removable sections are required, use hypalon gaskets with silicone mastic.

2.06 SOUND TRAPS

A. Acoustic Performance: Ratings shall be determined in a duct-to-reverberant room test facility which provides for airflow in both directions through the test sound trap in accordance with ASTM Specification E 477-96. The test set-up and procedure shall be such that all effects due to end reflection, directivity, flanking transmission, standing waves and test chamber sound absorption are eliminated. Acoustic ratings shall include Dynamic Insertion Loss (DIL) and Self-Noise (SN) Power Levels for forward flow (air and noise in same direction) with airflow of at least 2000 fpm entering face velocity. Test laboratory shall be NVLAP accredited or ETL certified.

B. Aerodynamic Performance: Static pressure loss of sound trap shall not exceed that listed in the schedule at the airflow indicated. Airflow measurements shall be made in accordance with ASTM Specification E 477 and applicable portions of ASME, AMCA, and ADC airflow test codes.

C. Certification: With submittals, supply NVLAP or ETL Laboratory certified test data on dynamic insertion loss, self-noise power levels, and aerodynamic performance for reverse and forward flow test conditions. Test data shall be for a standard product. Perform test on each type of sound traps and submit results for review.

D. Packed Sound Traps:
   2. Seams: Lock formed, mastic filled.
   4. Filler: inorganic mineral or glass fiber, 5 percent minimum compression, inert, vermin- and moisture-proof.
   5. Filler combustibility ratings: Maximum when tested per ASTM E 84, NFPA Std. 255 or UL No. 723: Flamespread 25; smoke developed 15; fuel contributed 20.
   6. Fillers. Filler sealed inside a polymer sheeting. Polymer sheeting shall be non-erosive, non-pregnable, mylar or tedlar of approximately 1.5 mils thickness and shall completely cover all fill. The encapsulated fill shall be separated from the interior perforated baffles by a factory-installed stand-off.
   7. Performance: as shown on the drawings.
   8. Provide Type 316L stainless steel construction for general laboratory and fume/biosafety cabinet exhaust fans, and where indicated.

E. Packless Sound Traps: Same as General Application packed sound traps above except:
   1. Casing and Partitions: As appropriate for the application.
2. Filler: None.

3. Performance: as shown on the drawings.

2.07 DUCT LINER

A. See Section 230713

PART 3 - EXECUTION

3.01 DUCTWORK

A. Where not otherwise specified herein, shown, noted, or required by codes, work shall conform to "HVAC Duct Construction Standards, Metal and Flexible," latest edition, as published by the Sheet Metal and Air Conditioning Contractors National Association, Inc. (SMACNA).

1. 4 inches (100 mm) w.g. class for herein specified medium pressure ductwork.

2. 2 inches (50 mm) w.g. class for herein specified low pressure ductwork.

3. At the Subcontractor’s option, round ducts may be substituted for rectangular ducts or rectangular ducts may be substituted for round ducts, providing that the substituted duct has a cross-sectional area of the original duct. As with other substitutions, the Subcontractor bears the responsibility for equivalency, fit, clearances, coordination, etc.

B. Construction Indoor Air Quality:

1. Follow control measures of SMACNA IAQ Guidelines for Occupied Buildings Under Construction, Chapter 3, latest edition as described in Agreement for Mechanical and Control Design-Build Project Section "Construction IAQ Management Plan".

2. Protect stored on-site or installed absorptive materials from moisture damage.

3. After fabrication in the shop, wipe down interior of each piece of supply air and return air ductwork with a lint-free rag, using a solution of 30 percent isopropyl alcohol and 70 percent water. Cap/seal supply, return, and exhaust air duct openings immediately after fabrication or cleaning. Schedule deliveries to the job site to match installation to avoid excessive storage at the job site. Store ductwork at the job site in closed trailers or in the immediate area in which it will be installed. Ducts at the site that have opening seals perforated are to be re-cleaned per shop cleaning requirements and re-sealed until needed for installation. Maintain caps/seals on openings of installed ducts. If openings of installed ducts have their seals perforated, re-clean contaminated duct sections per shop cleaning requirements. Demonstrate the cleanliness quality control.

4. Prior to operating air handling systems, verify internal cleanliness of air handlers, plenums, and ducts, and that filters are in place. Contamination requires re-
cleaning per shop cleaning requirements. Demonstrate to the Owner the cleanliness of the systems before operation. Provide security protocol to limit access to systems to avoid contamination.

5. No supply, return, or exhaust air systems are to be operated without the specific permission of the Owner.

6. Provide filtration at return and exhaust air inlets of systems that are operated prior to completion of construction. Filtration shall have a Minimum Efficiency Reporting Value (MERV) of 8, as determined by ASHRAE 52.2-1999.

7. After construction ends and prior to occupancy, conduct a minimum two-week building flush-out with new specified filtration media at 100 percent outside air.

C. Duct Placement and Fittings:

1. Fabricate ducts to net inside clear dimensions using specified sizes. Where internal duct liner is used, enlarge duct sizes so that specified sizes result in net clearance dimensions inside lining.

2. Form transitions with uniform taper not exceeding 15 degree included angle, unless shown otherwise on Drawings.

3. Offsets over 15 degrees shall have two radius turns or square turning vanes.

4. Where it is not possible to insulate ducts after installation, ducts shall be insulated before final installation. Tightness of work will not be accepted as a valid reason for omitting insulation. Where insulation is omitted, ducts will be removed, insulated and reinstalled.

5. Exposed Ducts: Exercise extreme care to produce neat and pleasing-in-appearance joints, connections, supports and other modifications. Ducts shall have no offsets, dents or dings. They shall be clean and grease-free. Remove excess sealant. Appearance must be acceptable to the Owner.

6. Install ducts true to line and grade.

7. Make changes of direction by curved sections with inside radius equal to duct width or square elbows with turning vanes as shown. Where square elbows are definitely shown, radius turns may not be used.

8. Closely fit and accurately place ducts and coordinate with work of other trades. Ducts must be so placed that piping, ceiling support grid, ceilings, and light fixtures may be installed without warping, springing or deforming ducts.

9. Angles and standing seams on ducts exposed in occupied areas shall have the corners chamfered 45 degrees with 1/4" rounded edges and ground smooth.

10. Seal duct penetrations through walls and floors.
11. Provide inlet and outlet duct transitions at reheat coils, constant, variable, and airflow control terminal whether or not such transition is shown on the drawings.

12. Provide openings in ductwork where required to accommodate sensors.

13. Closely coordinate roof penetrations with architectural details.

14. Provide 6 ft long stainless steel duct for the humidifier section. Slope duct downstream and provide drain outlet at low end of duct. Pipe drain outlet to an approved receptor. Provide 2 inch trap at the drain line.

D. Low Pressure Rectangular Ductwork:

1. Longitudinal seams: Flat crimped Pittsburgh lock with specified sealant, applied over seam.

2. Transverse Joints: Ductmate 35, TDC, or equal with specified gasket.

3. Cross break or bead sides.

4. Construction and Reinforcement:

<table>
<thead>
<tr>
<th>Largest Dimension of Duct</th>
<th>US STD. Gauge GSM</th>
<th>Max. Joint Spacing</th>
<th>Transverse Joint Size</th>
<th>Intermediate Angle Stiffener1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thru 12 inches (Thru 355 mm)</td>
<td>26 (0.7 mm)</td>
<td>96 inches (2438 mm)</td>
<td>As specified</td>
<td>None</td>
</tr>
<tr>
<td>13 to 30 inches (330 to 762 mm)</td>
<td>24 (0.7 mm)</td>
<td>60 inches (1524 mm)</td>
<td>As specified</td>
<td>None</td>
</tr>
<tr>
<td>31 to 36 inches (787 to 914 mm)</td>
<td>22 (0.85 mm)</td>
<td>60 inches (1524 mm)</td>
<td>As specified</td>
<td>None</td>
</tr>
<tr>
<td>37 to 48 inches (940 to 1220 mm)</td>
<td>20 (1 mm)</td>
<td>60 inches (1524 mm)</td>
<td>As specified</td>
<td>None</td>
</tr>
<tr>
<td>49 to 60 inches (1245 to 1524)</td>
<td>18 (1.31 mm)</td>
<td>60 inches (1524 mm)</td>
<td>As specified</td>
<td>None</td>
</tr>
<tr>
<td>61 to 84 inches2 (1550 to 2134 mm)</td>
<td>18 (1.31 mm)</td>
<td>60 inches (1524 mm)</td>
<td>1-1/2 by 1-1/2 by 1/8 inches (38 by 38 by 3 mm)</td>
<td></td>
</tr>
</tbody>
</table>

1 Required on four sides. Weld or bolt angles where they join. Mild steel.

2 Provide 3/8 inches (10 mm) diameter tie rods maximum 36 inches (914 mm) o.c. at each joint.
E. Medium Pressure Rectangular Ductwork:

1. Longitudinal seams: Same as for low pressure ductwork.

2. Transverse Joints Ductmate 35, TDC, or equal, with specified gaskets.

3. Cross break or bead sides of ducts.

4. Seal flanged joints, companion angle joints, and Ductmate joints with specified gasket material, triple lapped at corners. Torque bolts evenly to 1/16" compression of tape. Alternate: Apply 3/8" bead of specified sealant to both faces before bolting.

5. Construction and Reinforcement:

<table>
<thead>
<tr>
<th>Largest Dimension of Duct</th>
<th>US STD. Gauge GSM</th>
<th>Max. Joint Spacing</th>
<th>Transverse Joint Size</th>
<th>Intermediate Angle Stiffener¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thru 12 inches (Thru 355 mm)</td>
<td>24 (0.7 mm)</td>
<td>60 inches (1524 mm)</td>
<td>As specified</td>
<td>None</td>
</tr>
<tr>
<td>13 to 18 inches (330 to 457 mm)</td>
<td>22 (0.85 mm)</td>
<td>60 inches (1524 mm)</td>
<td>As specified</td>
<td>None</td>
</tr>
<tr>
<td>19 to 24 inches (483 to 610 mm)</td>
<td>22 (0.85 mm)</td>
<td>60 inches (1524 mm)</td>
<td>As specified</td>
<td>None</td>
</tr>
<tr>
<td>25 to 36 inches (635 to 914 mm)</td>
<td>24 (0.7 mm)</td>
<td>60 inches (1524 mm)</td>
<td>As specified</td>
<td>1-1/2 by 1-1/2 by 1/8 inches (38 by 38 by 3 mm)</td>
</tr>
<tr>
<td>37 to 48 inches (940 to 1220 mm)</td>
<td>22 (0.85 mm)</td>
<td>60 inches (1524 mm)</td>
<td>As specified</td>
<td>1-1/2 by 1-1/2 by 1/8 inches (38 by 38 by 3 mm)</td>
</tr>
<tr>
<td>49 to 60 inches (1245 to 1524 mm)</td>
<td>20 (1 mm)</td>
<td>60 inches (1524 mm)</td>
<td>As specified</td>
<td>2 by 2 by 3/16 inches (50 by 50 by 4.7 mm)</td>
</tr>
<tr>
<td>61 to 96 inches² (1550 to 2438 mm)</td>
<td>18 (1.31 mm)</td>
<td>60 inches (1524 mm)</td>
<td>As specified</td>
<td>2-1/2 by 2-1/2 by 3/16 inches (62 by 62 by 4.7 mm)</td>
</tr>
<tr>
<td>Over 96 inches³/⁴ (Over 2438 mm)</td>
<td>16 (1.61 mm)</td>
<td>48 inches (1220 mm)</td>
<td>3 by 3 by 3/16 inches C.F. (75 by 75 by 4.7 mm)</td>
<td>3 by 3 by 3/16 inches (75 by 75 by 4.7 mm)</td>
</tr>
</tbody>
</table>

¹ Required on four sides. Weld or bolt angles where they join. Mild steel.
2. Provide 3/8 inches (10 mm) diameter tie rods maximum 36 inches (914 mm) o.c. at each joint.

3. Weld 24 (610 mm) long 3/4 (18 mm) round knee brace inside duct at each corner to intermediate stiffener 8 feet (2.4 m) on center.

C.F. = Companion angle flanges.

F. Round Ductwork - HVAC:

1. Provide spiral round ductwork where shown on the Drawings.

2. Duct Gauges:

<table>
<thead>
<tr>
<th>Size</th>
<th>Low Pressure</th>
<th>Medium Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thru 8 inches (Thru 200 mm)</td>
<td>26</td>
<td>26</td>
</tr>
<tr>
<td>9 to 14 inches (230 to 355 mm)</td>
<td>26</td>
<td>26</td>
</tr>
<tr>
<td>14 to 26 inches (355 to 660 mm)</td>
<td>26</td>
<td>24</td>
</tr>
</tbody>
</table>


   a. Low Pressure:
      1) Elbows: 26 gauge smooth. Pleated not allowed.
      2) Other: 26 gauge Uniweld. Spot welded and sealed joints.

   b. Medium Pressure:
      1) Elbows: 20 gauge die-stamped. Spot welded and sealed joints.
      2) Other: 20 gauge Uniform. Spot welded and sealed joints.
      3) 16 gauge fittings shall be continuously welded.

   c. Elbows: Radius to center of duct shall not be less than 1.5 times the diameter of the duct.


   e. Tees: Conical tap machine formed to short flow nozzle shape.

   f. Laterals: Machine formed to ASME short flow nozzle, conical tap at 45 degrees F.

   g. Round tap fittings: Saddle type for round duct or conical for rectangular ducts as shown on the Drawings.
4. Round Duct Joints: Join by means of couplings with swaged bead in center and secured with sheet metal screws at each end of coupling. Make duct-to-fittings joints by either a tight slip fit of the fitting lapped inside the duct or by means of couplings with swaged bead in center, secured with sheet metal screws. Screw spacing: 6 inches (150 mm) unless otherwise shown on the Drawings. Seal joints and seams with specified internal sealant applied continuously around the coupling.

5. Option: The use of insulated Alumaflex for the low pressure duct downstream of the VAV terminals serving the office areas (AHU-3 system) is acceptable.

G. Plenums:

1. Fabricate plenums and access doors as shown on the Drawings or per manufacturer's directions.

2. Plenum roofs shall be able to support people load.

3. Provide air lock vents in access doors where required for air lock access application.

4. Openings for fans and ductwork connections where required shall be provided by the plenum manufacturer. Pipes and conduit penetrations shall be located and cut in the field and sealed in accordance with the manufacturer's instructions.

5. Provide for expansion compensation and building structure deflection for plenum panels spanning from floor to structure above.

6. Seismically brace all free-standing plenums.

H. Duct Support

1. Attachments to Structure: See Division 23 Section "Hangers and Supports for HVAC Piping and Equipment". Minimum rod or bolt size is 3/8 (9 mm).

2. Suspend horizontal galvanized rectangular ductwork 48 inches (1220 mm) or less in largest dimension from construction by 1 inch by 18 gauge (25 mm by 1.3 mm) galvanized strap hangers screwed 8 inches (200 mm) o.c. to ducts. Use three screws minimum per strap. Bend strap under duct and screw into bottom of duct.

3. Suspend horizontal rectangular stainless steel and coated ductwork 48 inches (1220 mm) or less in largest dimension from construction by 1 inch by 18 gauge (25 mm by 1.3 mm) galvanized steel strap hangers bolted to mating flanges at minimum of three locations. (Top, middle, and bottom).

4. Ducts over 48 inches (1220 mm) in largest dimension support from Unistrut, Superstrut, or equal, trapeze hangers sized for the load, per SMACNA standards.

5. Support round steel ductwork from construction by 1 inch by 18 gauge (25 mm by 1.3 mm) galvanized strap hangers with inside radius of loop hanger equal to...
outside radius of duct. For ducts under 12” diameter, provide supports 10 feet (3 m) o.c.; 12 feet (3.6 m) and over, 6 feet (1.8 m) o.c. Provide not less than one hanger per branch and at each change of direction.

6. Support round flexible ductwork from construction by 2 inches by 26 gauge (50 mm by 0.55 mm) galvanized strap hangers with inside radius of loop hanger equal to outside radius of duct. Locate supports to avoid kinks and sharp bends.

7. Double fold straps at attachment to structure.

8. Space Hangers not over 96 inches (2440 mm) on center for ducts smaller than 18 inches (457 mm) in largest dimension; 60 inches (1524 mm) o.c. for ducts 18 inches (457 mm) and over.

I. Sound Traps

1. Bolt sound traps together a required to form one assembly.

2. Connect to ductwork with joints specified for the duct pressure class.

J. Weather Protection:

1. Cover galvanized ducts and plenums at the roof with 20 gauge (1 mm) galvanized sheet metal.
   a. Pitch to drain.
   b. External covers at least 2 inches (50 mm) beyond edges of protected ducts and plenums.
   c. Overlap and seal covering materials.
   d. Support at duct reinforcement intervals.

3.02 SEALING

A. Where firestopping is not required, seal duct, pipe, and conduit penetrations through partitions with G.E. silicone sanitary sealant, Dow Corning 8650 Interior Sealant, or equal.

1. Provide 0.125- to 0.25-inch (3 mm to 6 mm) gap to be filled with specified sealant for noise control.

2. Seal duct penetrations through acoustical partition with acoustical sealant as specified in Division 7.

B. Seal ducts to the following seal classes according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible":

1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
2. Outdoor, Supply-Air Ducts: Seal Class A.

3. Outdoor, Exhaust Ducts: Seal Class C.

4. Outdoor, Return-Air Ducts: Seal Class C.

5. Unconditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class B.

6. Unconditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class A.

7. Unconditioned Space, Exhaust Ducts: Seal Class C.

8. Unconditioned Space, Return-Air Ducts: Seal Class B.

9. Conditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class C.

10. Conditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class B.

11. Conditioned Space, Exhaust Ducts: Seal Class B.

12. Conditioned Space, Return-Air Ducts: Seal Class C.

C. Do not seal at fire dampers in a way that violates UL or code installation requirements.

3.03 GALVANIZING REPAIRS

A. Repair galvanizing damaged by welding, scratches, etc., using Z.R.C., no known equal, cold galvanizing compound.

3.04 WASTE MANAGEMENT

A. Conform with Agreement for Mechanical and Control Design-Build Project Section "Construction Waste Management."

B. Collect off cuts and scrap and place in designated areas for recycling.

C. Separate other materials, including packaging and banding, in accordance with the Waste Management Plan and place in designated areas for recycling.

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY

A. Related Documents:

1. Drawings and general provisions of the Subcontract apply to this Section.
2. Review these documents for coordination with additional requirements and information that apply to work under this Section.

B. Section Includes:

1. Volume-control dampers
2. Flexible duct
3. Air-turning devices
4. Flexible duct connections
5. Duct access doors
6. Duct test holes
7. Insect screen
8. Control dampers

C. Related Sections:

1. Agreement for Mechanical and Control Design-Build Project
2. Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment".
3. Division 23 Section "Metal Ducts".
4. Division 23 Section "Air Terminal Units" for medium- and high-pressure damper assemblies.

1.02 REFERENCES

A. General:
1. The following documents form part of the Specifications to the extent stated. Where differences exist between codes and standards, the one affording the greatest protection shall apply.

2. Unless otherwise noted, the referenced standard edition is the current one at the time of commencement of the Work.

3. Refer to Agreement for Mechanical and Control Design-Build Project.

4. Refer to Division 23 Section "Common Results for HVAC" for codes and standards, and other general requirements.

   1. 29 CFR 1910.7 Definitions and Requirements for a Nationally Recognized Testing Laboratory (NRTL)

C. National Fire Protection Association (NFPA):
   1. NFPA 90A Installation of Air Conditioning and Ventilating Systems

D. Sheet Metal and Air Conditioning Subcontractors National Association (SMACNA)
   1. SMACNA HVAC Duct Construction Standards

E. Underwriters Laboratories Inc. (UL):
   1. UL 33 Heat Responsive Links for Fire-Protection Service

F. UL 555 Fire Dampers

1.03 SUBMITTALS

A. Submit under provisions of Division 23 Section "Common Results for HVAC, Review of Materials and Agreement for Mechanical and Control Design-Build Project Section "General Requirements."

B. Submit shop drawings and product data documentation of recycled content, MSDS showing VOC content under provisions of Agreement for Mechanical and Control Design-Build Project Section "General Requirements".

C. Shop Drawings: For shop-fabricated assemblies indicated, including volume-control dampers, duct access doors, etc.

D. Product Data: Provide product data for hardware used and include manufacturer’s installation instructions for combination fire and smoke dampers.
PART 2 - PRODUCTS

2.01 VOLUME-CONTROL DAMPER FABRICATION

A. Fabricate in accordance with SMACNA HVAC Duct Construction Standards, and as indicated on the Drawings.

B. Fabricate single-blade dampers for duct sizes to 30 inches wide. Shaft shall be continuous.

C. Fabricate multi-blade damper of opposed-blade pattern. Assemble center- and edge-crimped blades in prime-coated or galvanized channel frame with suitable hardware. Shaft shall be continuous.

D. Except in round ductwork 12 inches and smaller, provide end bearings. On multiple blade dampers, provide oil-impregnated nylon or sintered-bronze bearings.

E. Provide locking, indicating-quadrant regulators on single- and multi-blade dampers. Where rod lengths exceed 30 inches, provide regulator at both ends.

F. On insulated ducts, mount quadrant regulators on stand-off mounting brackets, bases, or adapters.

G. Volume dampers in Stainless Steel Ducts: All Type 316 stainless steel. Install so that free draining of ductwork is not obstructed. Provide Ventlok 641 Hi-Vel, airtight, self-locking regulator, and Ventlok 609 Hi-Vel damper end bearing, Elgen, or equal.

H. Where access to damper operators on ducts is not possible, provide remote operators, Ventlok Number 666, Elgen, or equal, securely fastened to ceiling or wall construction so that face of damper operator box is flush with finished surface of wall or ceiling.

2.02 ACCEPTABLE MANUFACTURERS - FIRE DAMPERS AND COMBINATION FIRE AND SMOKE DAMPERS

A. Ruskin, Greenheck or equal.

B. Substitutions: Under provisions of Agreement for Mechanical and Control Design-Build Project Section "General Requirements."

2.03 SMOKE DAMPER FABRICATION

A. Smoke dampers shall meet the requirements of NFPA90A, 92A, and 92B, and shall be classified as smoke dampers in accordance with the latest version of UL 555S. The leakage rating under UL555S shall be Leakage Class 1.

B. The dampers shall be AMCA licensed for Air Performance and shall bear the AMCA Certified Ratings Seal. Also, the dampers and their actuators shall be qualified in accordance with UL555S to an elevated temperature of 250°F (121°C). Appropriate electric actuators shall be installed by the damper manufacturer at time of damper fabrication. Electric actuators, factory installed on dampers, shall have been tested for prolonged periods of holding (minimum 1 year) with no evidence of reduced spring return.
performance. Each damper shall be rated for leakage and airflow in either direction through the damper.

C. Damper frame shall be minimum 16 gage galvanized steel formed into a hat-shaped channel structurally superior to 13 gage channel frame and reinforced at corners. Damper blades shall be airfoil shaped single piece construction with 13 gage equivalent thickness. Bearings shall be stainless steel sleeve turning in an extruded hole in the frame. Blade edge seals shall be inflatable silicone coated fiberglass and galvanized steel mechanically locked into blade edge (adhesive or stainless steel compression type). Dampers shall be Ruskin Model SD60, Greenheck, or equal.

D. California State Fire Marshal No.: 3230-245:110.

2.04 CONTROL DAMPER FABRICATION

A. Insulating Control Damper

1. Model: Ruskin CD40x2, Greenheck or equal.

2. Frame: 8-1/8 inches x 1 inch x minimum 0.081 inch (206 x 25 x minimum 2.1 mm) 6063-T5 extruded aluminum hat-shaped channel, mounting flanges on both sides of frame, reinforced at corners.
   a. Thermal Break: Thermal gasket break to prevent heat transmission through frame.

3. Blades:
   a. Sets: Minimum 2 sets with minimum 4 inches (102 mm) dead air space between sets.
   c. Action: Opposed.
   d. Orientation: Horizontal.
   e. Material: Heavy duty 6063-T5 extruded aluminum.
   f. Width: Maximum 4 inches (102 mm).


5. Seals:

7. Axles: Minimum 1/2 inch (13 mm) diameter plated steel, hex-shaped, mechanically attached to blade.


10. Performance Data:
   a. Temperature Rating: -50 to 250 degrees F.
   b. Capacity: Demonstrate capacity of damper to withstand HVAC system operating conditions.
      1) Closed Position: Maximum pressure of 13 inches w.g.
      2) Open Position: Maximum air velocity of 6,000 feet per minute.
   c. Leakage: Maximum 5.0 cubic feet per minute per square foot at 1 inch w.g. for all sizes 12 inches wide and above.
   d. Pressure Drop: Maximum 0.08 inch w.g. at 1,500 feet per minute across 24 inch x 24 inch damper.

11. Accessories
   a. Actuator:
      1) Coordinate requirements with Section 250000
      2) Fail Position: See control drawing.
      3) Mounting: External sideplate.
   b. SP 100 Switch Package: Two position indicators switches linked directly to damper blade to remotely indicate damper blade position.
   c. Factory Sleeve: Minimum 20 gage thickness, minimum 12 inches length.

B. See smoke damper fabrication.

C. Mount damper actuator in Type 304 stainless steel NEMA 4X housing for outdoor installation.

2.05 FLEXIBLE DUCTWORK

A. Flexmaster Type 8M, Thermoflex, or equal, with mechanically locked CPE fabric to helical wound galvanized steel without the use of adhesives or chemicals, 1" thick, 1
2.06 AIR-TURNING DEVICES

A. Turning Vanes (in Supply Duct Only): 90 degree, non-adjustable double thick turning vanes fabricated and installed in accordance with SMACNA "HVAC Duct Construction Standards". Vanes shall run full diagonal dimension of elbow with first vane tight in heel corner. Turning vanes shall not be used in exhaust ductwork (use radius elbow instead).

2.07 FLEXIBLE DUCT CONNECTIONS

A. Duct Flexible Connections for Interior Applications: Ventfab Number 3002, Elgen SDN-4, or equal, neoprene coated fiberglass fabric applied according to manufacturer's recommendations. Provide sheet metal bands or metal-edged fabric.

2.08 DUCT ACCESS DOORS

A. Fabricate in accordance with SMACNA HVAC Duct Construction Standards and as indicated on the drawings.

B. Review locations prior to fabrication.

C. Fabricate rigid and close-fitting doors of galvanized steel with sealing gaskets and quick-fastening locking devices. For insulated ductwork, install at least 1-inch (25-mm) thick insulation with sheet metal cover.

D. Access doors smaller than 12-inches (300-mm) square may be secured with sash locks.

E. Provide two hinges and two sash locks for sizes up to 18-inches (450-mm) square, three hinges and two compression latches with outside and inside handles for sizes up to 24 x 48 inches. Provide an additional hinge for larger sizes.

F. Access doors with sheet-metal screw fasteners are not acceptable.

G. Acceptable Manufacturers: Air Balance, Ruskin, or equal.

2.09 DUCT TEST HOLE FABRICATION

A. Cut or drill temporary test holes in ducts as required. Cap with neat patches, neoprene plugs, threaded plugs, or threaded or twist-on metal caps.

B. Permanent test holes shall be factory-fabricated, air-tight flanged fittings with screw cap. Provide extended-neck fittings to clear insulation.
PART 3 - EXECUTION

3.01 INSTALLATION

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

B. Flexible Connections: Where shown on the Drawings, and where otherwise required, shall be constructed as hereinbefore specified and applied in accordance with manufacturer’s recommendations. The width of the flexible connections shall be sufficient to allow two inches of free space between the two collars to be connected. Install a sheet metal band completely around the duct, or fan outlet and inlet, at each end of the flexible connections and fasten to the duct and fan with sheet metal screws through the band, or use metal-edged fabric of required width. Space screws approximately 3 inches apart. Seal all flexible connections with sealant as for duct seams. Stitch longitudinal seam in fabric with double 1/4 inch stitches and seal with approved adhesive. Install flexible connections at all duct connections to fans.

C. Duct Access Doors: Install in ducts, upstream and downstream of reheat coils, combination fire/smoke dampers, and where required for cleaning and for access to equipment and devices in ducts. Doors shall be airtight. Provide minimum 8 x 8 for hand access and 18 x 18 for shoulder access.

D. Flexible Duct: Use minimum length required. Use only where specifically shown. At diffusers, a maximum of two long radius 90 degree turns and a maximum length of 7 feet will be allowed. Support duct at each elbow. Secure at both ends with removable compression clamps. Size shall be as required by diffuser unless otherwise noted. Provide transition or transformation fittings as required for connections to sheet metal duct of diffuser.

E. Volume Dampers: Volume dampers are required on each branch of supply and exhaust ductwork. Install where shown on the Drawings. Where not specifically shown, install damper as far upstream from air outlet and downstream of air inlet as possible. Provide remote damper operator, whether noted on the Drawings or not, wherever volume dampers above the ceiling are not readily accessible. Installed dampers shall work freely without binding.

F. Fixed Turning Vanes: Install specified vanes in square elbows. Vanes shall run full diagonal dimension of elbow with first vane tight in heel corner. When turning vanes are installed in duct with internal insulation, install 20 gauge hat channels of same depth as insulation, and secure vane runners to channels. Design Builder fabricated turning vanes will not be acceptable.

G. Duct Smoke Detector: Duct smoke detector will be furnished and wired by the District. Install duct smoke detector on duct per code and manufacturer’s instruction. Duct smoke detector from fire/smoke dampers shall be located within 5 feet of the damper in accordance with code requirements.

H. Provide duct test holes where indicated on the drawings and required for testing and balancing.
3.02 WASTE MANAGEMENT

A. Conform with Agreement for Mechanical and Control Design-Build Project Section "Construction Waste Management".

B. Collect off cuts and scrap and place in designated areas for recycling.

C. Separate all other materials, including packaging and banding, in accordance with the Waste Management Plan and place in designated areas for recycling.

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY

A. Related Documents:

1. Drawings and general provisions of the Subcontract apply to this Section.
2. Review these documents for coordination with additional requirements and information that apply to work under this Section.

B. Section Includes:

1. Centrifugal fans
2. Drives
3. Belt guards
4. Access doors
5. Scroll drains

C. Related Sections:

1. Agreement for Mechanical and Control Design-Build Project
2. Division 23 Section "Common Results for HVAC".
3. Division 23 Section "Common Motor Requirements for HVAC Equipment".
4. Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment".
5. Division 23 Section "Ductwork Insulation".
6. Division 23 Section "Ductwork".
7. Division 23 Section "Testing, Adjusting, and Balancing for HVAC".

1.02 REFERENCES

A. General:
1. The following documents form part of the Specifications to the extent stated. Where differences exist between codes and standards, the one affording the greatest protection shall apply.

2. Unless otherwise noted, the referenced standard edition is the current one at the time of commencement of the Work.

3. Refer to Agreement for Mechanical and Control Design-Build Project.

4. Refer to Division 23 Section "Common Results for HVAC" for codes and standards, and other general requirements.

B. Air Movement and Control Association, Inc. (AMCA):
   1. AMCA 99 Standards Handbook
   2. AMCA 210 Laboratory Methods of Testing Fans for Rating
   3. AMCA 300 Reverberant Room Method for Sound Testing of Fans
   4. AMCA 301 Methods for Calculating Fan Sound Ratings from Laboratory Test Data

C. Anti-Friction Bearing Manufacturers Association (AFBMA):
   1. AFBMA 9 Load Ratings and Fatigue Life for Ball Bearings
   2. AFBMA 11 Load Ratings and Fatigue Life for Roller Bearings

D. Sheet Metal and Air Conditioning Contractors’ National Association, Inc. (SMACNA):
   1. SMACNA HVAC Duct Construction Standards

1.03 PERFORMANCE REQUIREMENTS

A. Fans used shall not decrease motor size, or increase tip speed by more than 10 percent, nor increase inlet air velocity by more than 20 percent, from specified criteria. Fans shall be capable of accommodating static-pressure variations of 10 percent. Fan motors shall be non-overloading through the entire range of operation. No change in motor size is allowed without approval from the Owner.

B. Base performance on sea level conditions.

1.04 SUBMITTALS

A. Submit under provisions of Division 23 Section "Common Results for HVAC, Review of Materials and Agreement for Mechanical and Control Design-Build Project.

B. Product Data:
1. Manufacturer’s literature on centrifugal fans and required accessories.

2. Certified fan curves from shutoff to free delivery with specified operating-point clearly plotted. Correct ratings for temperature and altitude where applicable.

3. Sound power levels for both fan inlet and outlet at rated capacity.

4. Confirmation of compatibility between fan and variable-frequency drive.

C. Operation and Maintenance Data: Include instructions for lubrication, motor and drive replacement, spare parts list, and wiring diagrams.

1.05 QUALITY ASSURANCE


B. Sound Ratings: AMCA 301, tested in accordance with AMCA 300.

C. Fabrication: AMCA 99.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver to site, store, and protect products under provisions of Division 23 Section "Common Results for HVAC".

B. Protect motors, shafts, and bearings from weather and construction dust.

PART 2 - PRODUCTS

2.01 CENTRIFUGAL FANS, GENERAL

A. Performance: As scheduled on the Drawings.

1. Provide direction of rotation, discharge direction, and arrangement conforming to the layouts shown on the Drawings.

2. Provide AMCA certified rating for performance and sound based on testing in an AMCA accredited laboratory.

2.02 WHEELS:

1. Steel.

2. Centrifugal fan blades continuously welded to the backplate.

3. Air foil, backward inclined or forward curved, as scheduled. See Drawings.

4. Hub keyed to shaft with set screws.

5. Cast aluminum.
B. Housings and bases (where applicable):
   1. Heavy gauge steel in accordance with AMCA 99.
   2. Inlets: Fully streamlined, with connection flanges or collars.
   4. Brace to prevent vibration or pulsation. Centrifugal fans are to be braced on the sides of the housings shall consist of structural angle iron extending the complete height of the unit.
   5. Continuously welded throughout. Spot welding is not acceptable.
   6. Fans shall be complete with a structural base supporting the fan and motor.
   7. Factory paint with prime coat and enamel finish.

C. Bearings:
   1. Heavy duty, split spherical roller in a one piece cast iron housing, or a double row spherical roller type in a two piece cast iron pillowblock for 18 inch wheel size and up. One piece housings and bearings for smaller sizes.
   2. Minimum L-10 life of 200,000 hours at maximum speed of fan's AMCA class.
   3. Support on heavy structural supports down to the structural base member of the fan.

D. Balance:
   1. Make both a static and dynamic balance after fan assembly at the factory.
   2. Vibration Amplitude: Factory test and provide report.

<table>
<thead>
<tr>
<th>RPM</th>
<th>Maximum Peak-to-Peak Displacement - Mils</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 600</td>
<td>2</td>
</tr>
<tr>
<td>600 - 1,000</td>
<td>1.5</td>
</tr>
<tr>
<td>over 1,000</td>
<td>1</td>
</tr>
</tbody>
</table>

3. See Division 23 Section "Testing, Adjusting, and Balancing for HVAC".

E. Provide accessories and options as specified below and as shown on the Drawings.
1. Provide all OSHA approved guards and screens as required by applicable codes.

2. Provide access points for shaft and motor RPM readings without disassembly.

3. Motors and drives shall be completely enclosed, ventilated and weatherproof for outdoor applications.

4. Type A, B or C spark resistant construction per AMCA 99, Standard 401, as specified hereinafter.

5. Exterior finish to be zinc-rich primer plus acrylic enamel, epoxy finish coat, or Hi-Pro polyester.

6. Interior finish to be same as exterior finish unless specified otherwise.

7. Where scroll drains are required, they shall be at the low point in the side panel and shall have a threaded connection.

8. Extended grease lines where bearings are not readily accessible.


2.03 V-BELT DRIVE

A. Cast iron or steel sheaves, dynamically balanced, and keyed. Provide fixed pitch sheaves, with matched belts, and drive rated as recommended by manufacturer, or minimum 1.5 times (or as otherwise specified) nameplate rating of the motor. Provide multiple belts where motor is larger than 10 hp, such that fan continues to operate with one broken belt.

2.04 BELT GUARD

A. Where required: Fabricate to SMACNA HVAC Duct Construction Standards; of 12 gauge (2.8 mm), 3/4 inch (20 mm) diamond-mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short circuiting vibration isolation, with provision for adjusting belt tension, lubrication, and use of tachometer with guard in place.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Do not operate fans for any purpose until ductwork is clean, filters are in place, bearings lubricated, and fan has been test run under observation.

B. Install fans as specified, with resilient mountings furnished under Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment," and flexible electrical leads.
C. Install flexible connections furnished under Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment", between fan inlet and discharge ductwork. Ensure metal bands of connectors are parallel with minimum 1 inch (25 mm) flex between ductwork and fan while running.

D. Install fume exhaust fan per the manufacturer's recommendations. Connect the fan airflow monitoring to the FMCS. Coordinate work with Section 255000.

E. Provide fixed sheaves required for final air balance.

F. Provide safety screen where inlet or outlet is exposed.

G. The installer of any equipment having bearings of any type shall be responsible for the protection and proper lubrication of the bearings before operation of their equipment. Give special attention to bearings in any equipment that has been delivered to the job site, or installed, in advance of completion. All bearing lubrication points shall be both visible and safely accessible after installation of equipment. Fit with proper lubrication fittings, and fill each pipe with proper lubricant.

3.02 ADJUSTING

A. Statically and dynamically balance fans to eliminate vibration or noise transmission to occupied areas.

B. Refer to Division 23 Section "Testing, Adjusting, and Balancing for HVAC".

3.03 MAINTENANCE AND OPERATING AND TRAINING INSTRUCTIONS

A. See Agreement for Mechanical and Control Design-Build Project.

END OF SECTION
SECTION 23 40 00
HVAC AIR CLEANING DEVICES

PART 1 - GENERAL

1.01 SUMMARY

A. Related Documents:

1. Drawings and general provisions of the Subcontract apply to this Section.

2. Review these documents for coordination with additional requirements and information that apply to work under this Section.

B. Section Includes:

1. Air filters for heating, ventilating and air conditioning.

C. Definitions: Refer to ASHRAE Standard 52.1 for definitions of face velocity, net effective filtering area, media velocity, resistance (pressure drop), atmospheric dust spot efficiency and dust-holding capacity. ASHRAE Standard 52.1 measures arrestance, dust spot efficiency and dust holding capacity of filters.

D. Refer to ASHRAE Standard 52.2 for definitions of MERV (Minimum Efficiency Reporting Value) PSE (Particle Size Efficiency) and particle size ranges for each MERV number. ASHRAE Standard 52.2 measures particle size efficiency (PSE).

1.02 RELATED WORK

A. General mechanical requirements and items, which are common to more than one section of Division 23: Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

B. Filter housing and racks:

1. Section 23 73 11, Central Station Air Handling Units with Coil

1.03 QUALITY ASSURANCE

A. Air Filter Performance Report for Extended Surface Filters:

1. Submit a test report for each Grade of filter being offered. The report shall not be more than three (3) years old and prepared by using test equipment, method and duct section as specified by ASHRAE Standards 52.1 and 52.2 for type filter under test and acceptable to Resident Engineer, indicating that filters comply with the requirements of this specification. Test for 150 m/min (500 fpm) will be accepted for lower velocity rated filters provided the test report of an independent testing laboratory complies with all the requirements of this specification.
B. Filter Supplier Warranty for Extended Surface Filters: Guarantee the filters against leakage, blow-outs, and other deficiencies during their normal useful life. Defective filters shall be replaced at no cost to the Government.

C. Comply with UL Standard 586 for flame test.

D. Filters shall maintain minimum initial efficiency after 6 weeks in service.

E. Nameplates: Each filter shall bear a label or name plate indicating manufacturer's name, filter size, rated efficiency, UL classification.

1.04 SUBMITTALS

A. Submit in accordance with Agreement for Mechanical and Control Design-Build Project requirements.

B. Manufacturer's Literature and Data:
   1. Extended surface filters.
   2. Holding frames. Identify locations.
   3. Side access housings. Identify locations, verify insulated doors.
   4. Magnehelic gages.

C. Air Filter performance reports.

D. Suppliers warranty.

E. Field test results for HEPA filters as per paragraph 2.3.E.3.

1.05 APPLICABLE PUBLICATIONS

A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by basic designation only.

B. American Society of Heating, Refrigerating and Air-conditioning Engineers, Inc. (ASHRAE):
   52.1-92 ....................................... Gravimetric and Dust-Spot procedures for Testing Air Cleaning Devices Used in General Ventilation for Removing Particulate Matter
   52.2-99 ....................................... Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size

C. American Society of Mechanical Engineers (ASME):
   NQA-1-02 ....................................... Quality Assurance Requirements for Nuclear Facilities Applications
D. Underwriters Laboratories, Inc. (UL):

586-00 ........................................ High-Efficiency, Particulate, Air Filter Units
900-99 ........................................ Air Filter Units

PART 2 - PRODUCTS

2.01 EXTENDED SURFACE AIR FILTERS

A. Use factory assembled air filters of the extended surface type with supported or non-supported cartridges for removal of particulate matter in air conditioning, heating and ventilating systems. Filter units shall be of the extended surface type fabricated for disposal when the dust-load limit is reached as indicated by maximum (final) pressure drop.

B. Filter Classification: UL approved Class 1 or Class 2 conforming to UL Standard 900.

C. Filter Grades, Percent, Average ASHRAE Efficiency and Controlled Containment:

1. Grade A: 90-95 after-filter, when handling 0.3 to 1.0 micron particles.
2. Grade B: 80-85 after-filter, when handling 0.3 to 1.0 micron particles.
3. Grade C: 50-65 pre-filter, when handling 1.0 to 3.0 micron particles.
4. Grade D: 25-35 pre-filter, when handling 3.0 to 10.0 micron particles.

D. Filter Media:

1. Grade A, B and C Supported (Rigid Pleated) Type: Media shall be composed of high density glass fibers or other suitable fibers. Fastening methods used to maintain pleat shape, (polyurethane bead separators) shall be sealed in a proper enclosing frame to insure no air leakage for life of filter. Staples and stays are prohibited.

2. Grade D (Pleated) Type: Media shall be composed of synthetic/natural fibers. Media shall maintain uniform pleat shape and stability for proper air flow and maximum dust loading. The media frame shall be constructed of aluminized steel. Bond the pleated media pack on all four edges to insure no air leakage for the life of the filter. Staples and stays are prohibited.

E. Filter Efficiency and Arrestance: Efficiency and arrestance of filters shall be determined in accordance with ASHRAE Standard 52.1, and MERV value in accordance with ASHRAE Standard 52.2. Atmospheric dust spot efficiency and synthetic dust weight arrestance shall not be less than the following:
Filter Efficiency, Arrestance and MERV Value

<table>
<thead>
<tr>
<th></th>
<th>Percentage of Initial Efficiency</th>
<th>Percentage of Average Efficiency</th>
<th>Percentage of Average Arrestance</th>
<th>MERV Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade A</td>
<td>75.4</td>
<td>86.4</td>
<td>99.0</td>
<td>14</td>
</tr>
<tr>
<td>Grade B</td>
<td>58.0</td>
<td>79.0</td>
<td>98.0</td>
<td>13</td>
</tr>
<tr>
<td>Grade C</td>
<td>25.0</td>
<td>53.0</td>
<td>97.0</td>
<td>11</td>
</tr>
<tr>
<td>Grade D</td>
<td>Less than 20.0</td>
<td>22.0</td>
<td>89.0</td>
<td>8</td>
</tr>
</tbody>
</table>

F. Maximum initial and final resistance, Pa (inches of water), for each filter cartridge when operated at 500 feet per minute face velocity:

<table>
<thead>
<tr>
<th>Filter Initial and Final Resistance (inch water column)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Resistance</td>
</tr>
<tr>
<td>Grade A (Rigid Mini Pleated)</td>
</tr>
<tr>
<td>Grade B (Rigid Mini Pleated)</td>
</tr>
<tr>
<td>Grade C1 (Rigid Mini Pleated)</td>
</tr>
<tr>
<td>Grade C2 (Rigid Pleated)</td>
</tr>
<tr>
<td>Grade D (2-inch deep)</td>
</tr>
<tr>
<td>Grade D (4-inch deep)</td>
</tr>
</tbody>
</table>

G. Minimum Media Area: The minimum net effective media area in square meter (square feet) for each 600 mm by 600 mm (24 inches by 24 inches) (face area) filter at 150 m/min (500 fpm) face velocity shall be at least the values listed below. For other filter sizes the net effective media area shall be proportionally higher or lower.

<table>
<thead>
<tr>
<th>Filter Media Area (square feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade A (Rigid Mini Pleated), 12-inch deep</td>
</tr>
<tr>
<td>Grade B (Rigid Mini Pleated) 12-inch deep</td>
</tr>
<tr>
<td>Grade C1 (Rigid Mini Pleated) 12-inch deep</td>
</tr>
<tr>
<td>Grade C2 (Rigid Pleated) 4-inch deep</td>
</tr>
<tr>
<td>Grade D 2-inch deep</td>
</tr>
<tr>
<td>Grade D 4-inch deep</td>
</tr>
</tbody>
</table>

H. Magnehelic Differential Pressure Filter Gages: Nominal four-inch diameter, zero to 500 Pa (zero to two inch water gage) range, flush mounted in aluminum panel board, complete with static tips, copper tubing, and accessory items to provide zero adjustment. Provide one gage for each extended surface filter section. Provide Petcocks for each gauge.

I. Equipment Identification: Section 230500, COMMON WORK RESULTS FOR HVAC.
PART 3 - EXECUTION

3.01 INSTALLATION

A. Install supports, filters and gages in accordance with manufacturer's instructions.

3.02 START-UP AND TEMPORARY USE

A. Clean and vacuum air handling units and plenums to the satisfaction of the Resident Engineer prior to starting air handling systems.

B. Install or deliver replacement filter units as directed by the Resident Engineer.

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY

A. Related Documents:

1. Drawings and general provisions of the Subcontract apply to this Section.

2. Review these documents for coordination with additional requirements and information that apply to work under this Section.

B. Section Includes:

1. Category IV flue gas exhaust system for condensing boilers.

2. Type B vent for domestic water heater.

3. All accessories from the boiler or water heater to the stack outlet to the atmosphere.

1.02 RELATED WORK:

A. Roof Penetrations: Section 07 60 00, FLASHING AND SHEET METAL.

B. Section 23 05 00, COMMON WORK RESULTS FOR HVAC.

1.03 QUALITY ASSURANCE:

A. Provide scale drawings showing nominal dimensions and weight of the systems.

B. Boiler and burner manufacturer shall review complete system from boiler flue gas outlet to stack outlet to atmosphere and advise the Government of any changes required to meet boiler and burner performance requirements. Note the altitude of plant site.

C. If a double wall, factory-fabricated, positive pressure breeching and stack system is provided, the manufacturer shall completely engineer the entire system and provide all components. Manufacturer’s representative shall provide installation instructions prior to start of construction train the installers and certify in writing to the Resident Engineer (RE)/Contracting Officers Technical Representative (COTR) that the entire installation complies with the official standards of the manufacturer and with the project specifications.
1.04 SUBMITTALS

A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

B. Design, materials, weights, construction, pressure and temperature limitations of breeching and stack systems. Seismic design data.

C. Drawings showing all components, system arrangement and dimensions.

D. Design, construction, allowable movements, movement forces, pressure and temperature limitations of expansion joints.

E. Damper design, construction, pressure and temperature limitations, pressure loss at design flow, and leakage of closed damper.

F. Support designs, locations and loads for entire assembly. Seismic design data.

G. Written statement from boiler/burner manufacturer that the design of the system is satisfactory to achieve the required boiler/burner performance.

1.05 APPLICABLE PUBLICATIONS:

A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.

B. American Institute of Steel Construction (AISC):

C. ASTM International (ASTM):
   A36/A36M-05 ....................... Carbon Structural Steel
   A242/A242M-04e1 .................. High-Strength Low-Alloy Structural Steel
   A307-07a.......................... Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength
   A563-07.......................... Carbon and Alloy Steel Nuts
   A568/A568M-07 .................. Steel, Sheet, Carbon, and High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, General Requirements For

D. American Welding Society (AWS):
   DI.1/D1.1M-2008 ................. Structural Welding Code-Steel

E. Manufacturer’s Standardization Society of the Valves and Fittings Industry (MSS):

F. NFPA 211.
PART 2 - PRODUCTS

2.01 CATEGORY IV

A. Refer to drawings for arrangement and dimensions. Ninety-degree tee sections are not permitted. Intersections must be made with lateral tees.

B. Service: Design for continuous 315 °C (600 °F), 12 kPa (50 inches WC) positive and negative internal pressure, wind-loading for outside stacks 85 mph wind. Design system and supports for seismic loads in accordance with Section 23 05 48.

C. Pre-engineered, Pre-Fabricated, Double-Wall System:

1. Complete factory-built system, all components and installation engineered and provided by manufacturer of system.

2. Corrosion-resistant steel, double-wall, circular cross section.

3. Factory-built standard sections, connected in the field with joining system designed and provided by system manufacturer. Designed to be pressure and vacuum-tight, no deformation, at the service conditions specified.

4. System manufacturer’s engineered support system, attached to structural members of the building, with expansion joints between rigid supports. Thermal expansion shall be handled by expansion joints and variable spring hangers. Thermal expansion and weight of system shall not impose loads in excess of that allowed by manufacturer of boiler, or any other equipment, or exceed capabilities of building structure. Spring hangers shall conform to MSS SP-58, Type 51, variable spring.

5. Inner Wall: AL29-4C stainless steel, 0.9 mm (0.035-inch) minimum thickness for diameters 900 mm (36 inches) and smaller and 1.2 mm (0.048 inches) minimum thickness for diameters greater than 900 mm (36 inches) and 1200 mm (48 inches) and less.

6. Outer Wall: Aluminized or galvanized steel except 304 stainless steel outside of building. 0.6 mm (0.025 inch) minimum thickness for inner wall diameter 800 mm (32 inches) and less, 0.9 mm (0.034 inch) minimum thickness for inner wall diameter over 800 mm (32 inches) and 1200 mm (48 inches) and less.

7. Uninsulated Air Space between Inner and Outer Walls: 25 mm (one inch) minimum.

8. Bands for Joining Sections: Same material as section being joined. Utilize sealant provided by system manufacturer.
9. Roof penetrations shall be manufacturer’s standard ventilated thimble. Conform to Section 07 62 00, “SHEET METAL FLASHING AND TRIM.”

10. Stack Outlet: Provide as shown, double cone rain cap or other type termination designed by manufacturer of the stack system.

11. Drain Section: Provide inside building below roof to drain rain water from stack. Extend drain pipe to floor drain.

2.02 CHIMNEYS FOR WATER HEATERS

A. AMPCO Ameri-vent, Metalbestos, or equal, Type B, double wall metal chimney, U.L. listed for use with building heating equipment burning gas as described in NFPA 211. Furnish a complete assembly including support hangers, roof penetration assembly, vertical pipe support, barometric damper, and flue caps.

B. Outer Wall: Minimum 28 gauge galvanized steel.

C. Inner Wall: Minimum 0.012” aluminum alloy.

D. Fittings, Couplings, Supports, Guides, and Terminations: Of same manufacturer as the double wall system, and covered under the UL listing.

2.03 ACCESSORIES

A. Drains: Provide threaded pipe connection to allow drainage at all low points and drain connections in stack and breeching systems. Slope piping system to the drain. Pipe size shall be 25 mm (1 inch) minimum.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Supports: Completely support all systems from the building structure without overloading the building structure or the connected equipment. Support system shall be engineered by the system manufacturer and shall accommodate thermal expansion. Refer to seismic requirements in Section 23 05 48.

B. Factory-Fabricated Stack or Breeching System:

1. Install in accordance with manufacturer’s printed instructions.

2. Deliver a copy of the instructions to the District’s Inspector of Record to commencing the installation.

3. Representative of manufacturer shall provide field training on all installation techniques to all installers.

C. Terminate vent with vent caps.
D. Connect 1 inch minimum pipes with ball valves to breeching and stack drains. Extend to nearest floor drain.

END OF SECTION
SECTION 23 52 12

GENERAL MOTOR REQUIREMENTS FOR HVAC AND STEAM GENERATION EQUIPMENT

PART 1 - GENERAL

1.01 DESCRIPTION

A. This section specifies the furnishing, installation and connection of motors for HVAC and steam generation equipment.

1.02 RELATED WORK:

A. Agreement for Mechanical and Control Design-Build Project, SHOP DRAWINGS, PRODUCT DATA and SAMPLES

B. Section 23 05 00, COMMON WORK RESULTS FOR HVAC

C. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS

D. Division 26

1.03 SUBMITTALS:

A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA and SAMPLES, and Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

B. Shop Drawings:
   
   1. Provide documentation to demonstrate compliance with drawings and specifications.

   2. Include electrical ratings, efficiency, bearing data, power factor, frame size, dimensions, mounting details, materials, horsepower, voltage, phase, speed (RPM), enclosure, starting characteristics, torque characteristics, code letter, full load and locked rotor current, service factor, and lubrication method.

C. Manuals:

   1. Submit simultaneously with the shop drawings, companion copies of complete installation, maintenance and operating manuals, including technical data sheets and application data.

D. Certification: Two weeks prior to final inspection, unless otherwise noted, submit four copies of the following certification to the Contracting Officer’s Representative:

   1. Certification that the motors have been applied, installed, adjusted, lubricated, and tested according to manufacturer published recommendations.
E. Completed System Readiness Checklists provided by the Commissioning Agent and completed by the contractor, signed by a qualified technician and dated on the date of completion, in accordance with the requirements of Section 23 08 00 COMMISSIONING OF HVAC SYSTEMS.

1.04 APPLICABLE PUBLICATIONS:

A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.

B. National Electrical Manufacturers Association (NEMA):

MG 1-2006 Rev. 1 2009 Motors and Generators


C. National Fire Protection Association (NFPA):

70-2008 National Electrical Code (NEC)

D. Institute of Electrical and Electronics Engineers (IEEE):

112-04 Standard Test Procedure for Polyphase Induction Motors and Generators

E. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE):


PART 2 - PRODUCTS

2.01 MOTORS

A. For alternating current, fractional and integral horsepower motors, NEMA Publications MG 1 and MG 2 shall apply.

B. All material and equipment furnished and installation methods shall conform to the requirements of Section 26 29 11, LOW-VOLTAGE MOTOR STARTERS; and Section 26 05 21, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES (600 VOLTS AND BELOW). Provide all electrical wiring, conduit, and devices necessary for the proper connection, protection and operation of the systems. Provide premium efficiency type motors as scheduled. Unless otherwise specified for a particular application, use electric motors with the following requirements.

C. Single-phase Motors: Motors for centrifugal fans and pumps may be split phase or permanent split capacitor (PSC) type. Provide capacitor-start type for hard starting applications.
1. Electrically Commutated motor (EC Type): Motor shall be brushless DC type specifically designed for applications with heavy duty ball bearings and electronic commutation. The motor shall be speed controllable down to 20% of full speed and 85% efficient at all speeds.


1. Two Speed Motors: Each two-speed motor shall have two separate windings. Provide a time-delay (20 seconds minimum) relay for switching from high to low speed.

E. Voltage ratings shall be as follows:

1. Single phase:
   a. Motors connected to 120-volt systems: 115 volts.
   b. Motors connected to 208-volt systems: 200 volts.
   c. Motors connected to 240 volt or 480 volt systems: 230/460 volts, dual connection.

2. Three phase:
   a. Motors connected to 208-volt systems: 200 volts.
   b. Motors, less than 100 HP, connected to 240 volt or 480 volt systems: 208-230/460 volts, dual connection.

F. Number of phases shall be as follows:

1. Motors, less than 1/2 HP: Single phase.
2. Motors, 1/2 HP and larger: 3 phase.
3. Exceptions:
   a. Hermetically sealed motors.
   b. Motors for equipment assemblies, less than one HP, may be single phase provided the manufacturer of the proposed assemblies cannot supply the assemblies with three phase motors.

G. Motors shall be designed for operating the connected loads continuously in a 104°F environment, where the motors are installed, without exceeding the NEMA standard temperature rises for the motor insulation. If the motors exceed 104°F, the motors shall be rated for the actual ambient temperatures.

H. Motor designs, as indicated by the NEMA code letters, shall be coordinated with the connected loads to assure adequate starting and running torque.
I. Motor Enclosures:

1. Shall be the NEMA types as specified and/or shown on the drawings.

2. Where the types of motor enclosures are not shown on the drawings, they shall be the NEMA types, which are most suitable for the environmental conditions where the motors are being installed. Enclosure requirements for certain conditions are as follows:
   a. Motors located outdoors, indoors in wet or high humidity locations, or in unfiltered airstreams shall be totally enclosed type.
   b. Where motors are located in an NEC 511 classified area, provide TEFC explosion proof motor enclosures.
   c. Where motors are located in a corrosive environment, provide TEFC enclosures with corrosion resistant finish.

3. Enclosures shall be primed and finish coated at the factory with manufacturer's prime coat and standard finish.

J. Special Requirements:

1. Where motor power requirements of equipment furnished deviate from power shown on plans, provide electrical service designed under the requirements of NFPA 70 without additional time or cost to the Government.

2. Assemblies of motors, starters, controls and interlocks on factory assembled and wired devices shall be in accordance with the requirements of this specification.

3. Wire and cable materials specified in the electrical division of the specifications shall be modified as follows:
   a. Wiring material located where temperatures can exceed 71 degrees C (160 degrees F) shall be stranded copper with Teflon FEP insulation with jacket. This includes wiring on the boilers.
   b. Other wiring at boilers and to control panels shall be NFPA 70 designation THWN.
   c. Provide shielded conductors or wiring in separate conduits for all instrumentation and control systems where recommended by manufacturer of equipment.

4. Select motor sizes so that the motors do not operate into the service factor at maximum required loads on the driven equipment. Motors on pumps shall be sized for non-overloading at all points on the pump performance curves.

5. Motors utilized with variable frequency drives shall be rated “inverter-duty” per NEMA Standard, MG1, Part 31.4.4.2. Provide motor shaft grounding apparatus...
that will protect bearings from damage from stray currents, as an option, motors with ceramic bearings are also acceptable in lieu of shaft grounding.

K. Additional requirements for specific motors, as indicated in the other sections listed in Article 1.2, shall also apply.

L. Energy-Efficient Motors (Motor Efficiencies): All permanently wired polyphase motors of 1 HP or more shall meet the minimum full-load efficiencies as indicated in the following table. Motors of 746 Watts or more with open, drip-proof or totally enclosed fan-cooled enclosures shall be NEMA premium efficiency type, unless otherwise indicated. Motors provided as an integral part of motor driven equipment are excluded from this requirement if a minimum seasonal or overall efficiency requirement is indicated for that equipment by the provisions of another section. Motors not specified as “premium efficiency” shall comply with the Energy Policy Act of 2005 (EPACT).

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M. Minimum Power Factor at Full Load and Rated Voltage: 90 percent at 1200 RPM, 1800 RPM and 3600 RPM.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install motors in accordance with manufacturer’s recommendations, the NEC, NEMA, as shown on the drawings and/or as required by other sections of these specifications.

3.02 FIELD TESTS

A. Perform an electric insulation resistance Test using a megohmmeter on all motors after installation, before start-up. All shall test free from grounds.

B. Perform Load test in accordance with ANSI/IEEE 112, Test Method B, to determine freedom from electrical or mechanical defects and compliance with performance data.

C. Insulation Resistance: Not less than one-half meg-ohm between stator conductors and frame, to be determined at the time of final inspection.

D. All test data shall be compiled into a report form for each motor and provided to the contracting officer or their representative.

3.03 STARTUP AND TESTING

A. The Commissioning Agent will observe startup and Design Builder testing of all equipment. Coordinate the startup and Design Builder testing schedules with Contracting Officer’s Representative and Commissioning Agent. Provide a minimum of 7 days prior notice.

3.04 COMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00 – COMMISSIONING OF HVAC SYSTEMS for all inspection, start up, and Design Builder testing required above and required by the System Readiness Checklist provided by the Commissioning Agent.

B. Components provided under this section of the specification will be tested as part of a larger system. Refer to Section 23 08 00 – COMMISSIONING OF HVAC SYSTEMS and related sections for Design Builder responsibilities for system commissioning.

3.05 DEMONSTRATION AND TRAINING

A. Provide services of manufacturer’s technical representative for four hours to instruct VA personnel in operation and maintenance of units.

B. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00 – COMMISSIONING OF HVAC SYSTEMS.
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END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY

A. Related Documents:

1. Drawings and general provisions of the Subcontract apply to this Section.

2. Review these documents for coordination with additional requirements and information that apply to work under this Section.

B. Section Includes:

1. Boilers.

2. Boiler trim.

3. Fuel burning equipment and connections.

4. Controls.

C. Related Sections:

1. Agreement for Mechanical and Control Design-Build Project Section - General Requirements

2. Agreement for Mechanical and Control Design-Build Project Section - Special Procedures

3. Division 23 Section - Hydronic Systems, and Breaching, Chimneys and Stacks

1.02 REFERENCED STANDARDS

A. General:

B. The following documents form part of the Specifications to the extent stated. Where differences exist between codes and standards, the one affording the greatest protection shall apply.

C. Unless otherwise noted, the referenced standard edition is the current one at the time of commencement of the Work.

D. Refer to Agreement for Mechanical and Control Design-Build Project Section "General Requirements" for the list of applicable regulatory requirements.
1. Refer to Section 230500 Section - Common Results for HVAC for codes and standards, and other general requirements.

   1. 10 CFR 430 Appendix N
   2. 29 CFR 1910.7 Definitions and Requirements for a Nationally Recognized Testing Laboratory (NRTL)

F. State of California Code of Regulations (CCR):
   1. CCR Title 8 Industrial Relations (Cal/OSHA): Ch 4. Division of Industrial Safety (DIS):
      a. SubCh 2. Boiler & Fired Pressure Vessel Safety Orders
      b. SubCh 5. Electrical Safety Orders

G. Bay Area Air Quality Management District (BAAQMD)
H. American National Standards Institute (ANSI)
   1. ANSI Z21.13 Gas-Fired Low-Pressure Steam and Hot Water Boilers – This limits the maximum hot water boiler turndown to no more than 20% or 5:1 turndown ratio, no less.

I. American Society of Mechanical Engineers (ASME):
   1. ASME BPVC Boiler and Pressure Vessel Code, Construction Sec I of Power Boilers
   2. ASME BPVC Boiler and Pressure Vessel Code, Construction Sec IV of Heating Boilers
   3. ASME BPVC Boiler and Pressure Vessel Code, Construction Sec VIII of Pressure Vessels

J. Hydronics Institute (HI):
   1. HI Testing and Rating Standard for Cast Iron and Steel Heating Boilers

K. ASME CSD-1 GE-GAP

L. National Board of Boiler and Pressure Vessel Inspectors (NBBPVI):
   1. NBBPVI 23 National Board Inspection Code

M. National Electrical Manufacturers Association (NEMA)
1. NEMA 250 Enclosures for Electrical Equipment (1000 Volt Maximum)

N. National Fire Protection Association (NFPA):
1. NFPA 54 National Fuel Gas Code
2. NFPA 58 Storage and Handling of Liquefied Petroleum Gases
3. NFPA 64 National Fuel Code
4. NFPA 70 National Electrical Code

O. Underwriters Laboratories, Inc. UL Gas and Oil Equipment Directory

1.03 SUBMITTALS

A. Submit under provisions of Section 15000 and Agreement for Mechanical and Control Design-Build Project.

B. Test Data:
1. Factory inspection and test reports as specified in subpart 2.17, ‘Source Quality Control.’
2. Field test report as specified in subpart 3.04, ‘Field Quality Control.’

C. Shop Drawings: Dimensioned and detailed drawings, including control wiring diagrams complete and specific for each boiler supplied.

D. Product Data: Include descriptive data, specifications, ratings, performance data, efficiency and pressure drop curve, installation instructions, and start-up instructions.

E. Operations and Maintenance Data:
1. Initial Submittal: Operating instructions, maintenance instructions, and parts list.
2. Closeout: Complete manuals.

1.04 QUALITY ASSURANCE

A. Manufacturer Qualifications: Firms regularly engaged in the manufacture of condensing hydronic boilers with welded steel pressure vessels, whose products have been in satisfactory use in service for not less than twenty-five (25) years. The manufacturer must be privately owned and headquartered in North America. Finished products manufactured in ASME-certified facility. The specifying engineer, Design Builder and end customer must have the option to visit the factory during the manufacture of the boilers and be able to witness test fire and other relevant procedures.

B. Aftermarket Support and Service: The manufacturer shall have a factory authorized service training program, where boiler technicians can attend a training class and obtain
certification to perform start-up, maintenance and basic troubleshooting specific to the product line. The boiler manufacturer shall have a minimum of 10 full time service technicians on staff.

C. Electrical Components, Devices and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

D. ASME Compliance: Fabricate and label boilers to comply with ASME Boiler and Pressure Vessel Code, Section IV “Heating Boilers”, for a maximum allowable working pressure of 160 PSIG.

E. CSD-1 Compliance: The boiler shall comply with ASME Controls and Safety Devices for Automatically Fired Boilers (CSD-1).

F. ASHRAE/IESNA 90.1 Compliance: Boilers shall have minimum efficiency according to “Gas and Oil Fired Boilers - Minimum Efficiency Requirements.”

G. UL Compliance: Boilers must be tested for compliance with UL 795, “Commercial-Industrial Gas Heating Equipment.” Boilers shall be listed and labeled by ETL.

H. AHRI Compliance: Boilers shall be tested and rated according to the BTS-2000 test standard and verified by AHRI.

I. NOx Emissions Compliance: Boiler shall be tested for compliance with BAAQMD.

J. The equipment shall be of the type, design, and size that the manufacturer currently offers for sale and appears in the manufacturer’s current catalog.

K. The equipment shall fit within the allocated space, leaving ample allowance for maintenance and inspection.

L. The equipment shall be new and fabricated from new materials. The equipment shall be free from defects in materials and workmanship.

M. All units of the same classification shall be identical to the extent necessary to ensure interchangeability of parts, assemblies, accessories, and spare parts wherever possible.

N. In order to provide unit responsibility for the specified capacities, efficiencies, and performance, the boiler manufacturer shall certify in writing that the equipment being submitted shall perform as specified.

1.05 DELIVERY, HANDLING, AND STORAGE

A. Protect boilers from damage by leaving factory inspection openings and shipping packaging in place until final installation.
1.06 OPERATING & MAINTENANCE MANUALS
   A. Provide four (4) Operating and Maintenance manuals including cut-away views of boiler and burner, schematics including fuel trains, general instructions for maintenance and inspections, complete spare parts lists and troubleshooting procedures.

   B. A wiring diagram corresponding to the boiler shall be affixed to the boiler near the electrical panel.

1.07 WARRANTY
   A. Standard Warranty: Manufacturer’s standard form in which manufacturer agrees to repair or replace components of boilers that fails in materials or workmanship within specified warranty period.

   1. Warranty Period for the Pressure Vessel and Heat Exchanger: The boiler manufacturer shall warranty against failure due to thermal shock, flue gas condensate corrosion, and/or defective material or workmanship for a period of 10 years, non-prorated, from the date of shipment from the factory provided the boiler is installed, controlled, operated and maintained in accordance with the Installation, Operation and Maintenance Manual.

   2. Warranty Period for all other components: The boiler manufacturer will repair or replace any part of the boiler that is found to be defective in workmanship or material within eighteen (18) months of shipment from the factory or twelve (12) months from start-up, whichever comes first.

PART 2 - PRODUCTS

2.01 MANUFACTURER
   A. This specification is based on the AERCO Benchmark, Cleaver Brooks CE, Fulton Endura, or equal. Equivalent units and manufacturers must meet all performance criteria, and will be considered upon prior approval.

   B. The boiler manufacturer shall have the capability to construct an engineered hydronic system, skid mounted, for the above referenced boilers incorporating single point electrical, supply water, return water, fresh water make up, fuel, and drain. The boiler manufacturer shall have the engineering capabilities for all aspects of the mechanical, electrical and control design aspects of the skid mounted system.

2.02 CONSTRUCTION
   A. Description: Boiler shall be natural gas fired, fully condensing, fire tube design. Power burner shall have full modulation (the minimum firing rate shall not exceed 50,000 BTU/HR input. Boilers that have an input greater than 50,000 BTU/Hr at minimum fire will not be considered) and discharge into a positive pressure vent. Boiler efficiency shall increase with decreasing load (output), while maintaining setpoint. Boiler shall be factory-fabricated, factory-assembled and factory-tested, fire-tube condensing boiler with heat exchanger sealed pressure-tight, built on a steel base, including insulated jacket, flue-gas
vent, combustion-air intake connections, water supply, return and condensate drain connections, and controls.

B. Heat Exchanger: The heat exchanger shall be constructed of 439 stainless steel fire tubes and tubesheets, with a one-pass combustion gas flow design. The fire tubes shall be 1/2” OD, with no less than 0.035” wall thickness. The upper and lower stainless steel tubesheet shall be no less than 0.25” thick. The pressure vessel/heat exchanger shall be welded construction. The heat exchanger shall be ASME stamped for a working pressure not less than 160 psig. Access to the tubesheets and heat exchanger shall be available by burner and exhaust manifold removal. Minimum access opening shall be no less than 6-inch diameter.

C. Pressure Vessel: The pressure vessel shall have a maximum water volume of 14.25 gallons. The boiler water pressure drop shall not exceed 2.5 psig at 87 gpm. The boiler water connections shall be 3-inch flanged 150-pound, ANSI rated. The pressure vessel shall be constructed of SA53 carbon steel, with a 0.25-inch thick wall and 0.50-inch thick upper head. Inspection openings in the pressure vessel shall be in accordance with ASME Section IV pressure vessel code. The boiler shall be designed so that the thermal efficiency increases as the boiler firing rate decreases.

D. Modulating Air/Fuel Valve and Burner: The boiler burner shall be capable of a 20-to-1 turndown ratio of the firing rate without loss of combustion efficiency or staging of gas valves. The burner shall produce less than 20 ppm of NOx corrected to 3% excess oxygen. The unit shall be certified by the South Coast Air Quality Management District (SCAQMD) as compliant with Rule 1146.2 for boilers and water heaters less than or equal to 2 MBTUs, and the Texas Commission on Environmental Quality (TCEQ) as being compliant with Section 117.465 for boilers and water heaters less than or equal to 2 MBTUs. The burner shall be metal-fiber mesh covering a stainless steel body with spark ignition and flame rectification. All burner material exposed to the combustion zone shall be of stainless steel construction. There shall be no moving parts within the burner itself. A modulating air/fuel valve shall meter the air and fuel input. The modulating motor must be linked to both the gas valve body and air valve body with a single linkage. The linkage shall not require any field adjustment. A variable frequency drive (VFD), controlled cast aluminum pre-mix blower shall be used to ensure the optimum mixing of air and fuel between the air/fuel valve and the burner.

E. Minimum boiler efficiencies shall be as follows at a 20 degree delta-T:

<table>
<thead>
<tr>
<th>EWT</th>
<th>100% Fire</th>
<th>50% Fire</th>
<th>5% Fire</th>
</tr>
</thead>
<tbody>
<tr>
<td>160 °F</td>
<td>87%</td>
<td>87.3%</td>
<td>87.6%</td>
</tr>
<tr>
<td>120 °F</td>
<td>90.5%</td>
<td>91%</td>
<td>91.5%</td>
</tr>
<tr>
<td>80 °F</td>
<td>97%</td>
<td>97.4%</td>
<td>97.5%</td>
</tr>
</tbody>
</table>

F. The exhaust manifold shall be of corrosion resistant cast aluminum with a 6-inch diameter flue connection. The exhaust manifold shall have a collecting reservoir and a gravity drain for the elimination of condensation.

G. Blower. The boiler shall include a variable-speed, DC centrifugal fan to operate during the burner firing sequence and pre-purge the combustion chamber.
1. Motors: Blower motors shall comply with requirements specified in Division 23 Section "Common Motor Requirements for HVAC Equipment."

   a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require a motor to operate in the service factor range above 1.0.

H. Ignition: Ignition shall be via regulated staged spark ignition with 100 percent main-valve shutoff and electronic flame supervision.

2.03 CONTROLS

A. The boiler control system shall be segregated into three components: "C-More" Control Panel, Power Box and Input/Output Connection Box. The entire system shall be Underwriters Laboratories recognized.

B. The control panel shall consist of six individual circuit boards using state-of-the-art surface-mount technology in a single enclosure. These circuit boards shall include:

   1. A display board incorporating LED display to indicate temperature and a vacuum fluorescent display module for all message enunciation
   2. A CPU board housing all control functions
   3. An electric low-water cutoff board with test and manual reset functions
   4. A power supply board
   5. An ignition /stepper board incorporating flame safeguard control
   6. A connector board

Each board shall be individually field replaceable.

C. The combustion safeguard/flame monitoring system shall use spark ignition and a rectification-type flame sensor.

D. The control panel hardware shall support both RS-232 and RS-485 remote communications.

E. The controls shall annunciate boiler and sensor status and include extensive self-diagnostic capabilities that incorporate a minimum of eight separate status messages and 34 separate fault messages.

F. The control panel shall incorporate three self-governing features designed to enhance operation in modes where it receives an external control signal by eliminating nuisance faults due to over-temperature, improper external signal or loss of external signal. These features include:

   1. Setpoint High Limit: Setpoint high limit allows for a selectable maximum boiler outlet temperature and acts as temperature limiting governor. Setpoint limit is
based on a PID function that automatically limits firing rate to maintain outlet
temperature within a 0 to 10 degree selectable band from the desired maximum
boiler outlet temperature.

2. Setpoint Low Limit: Setpoint low limit allows for a selectable minimum operating
temperature.

3. Failsafe Mode: Failsafe mode allows the boiler to switch its mode to operate from
an internal setpoint if its external control signal is lost, rather than shut off. This is
a selectable mode, enabling the control can to shut off the unit upon loss of
external signal, if so desired.

G. The boiler control system shall incorporate the following additional features for enhanced
external system interface:

1. System start temperature feature

2. Pump delay timer

3. Auxiliary start delay timer

4. Auxiliary temperature sensor

5. Analog output feature to enable simple monitoring of temperature setpoint, outlet
temperature or fire rate

6. Remote interlock circuit

7. Delayed interlock circuit

8. Fault relay for remote fault alarm

H. Each boiler shall include an electric, single-seated combination safety shutoff
valve/regulator with proof of closure switch in its gas train. Each boiler shall incorporate
dual over-temperature protection with manual reset, in accordance with ASME Section IV
and CSD-1.

I. Each boiler shall have an oxygen monitoring system that will measure the oxygen content
of the exhaust gasses in real-time. Output of O2 information shall be displayed on the C-
More control panel.

J. Each boiler shall have integrated Boiler Sequencing Technology (BST), capable of multi-
unit sequencing with lead-lag functionality and parallel operation. The system will
incorporate the following capabilities:

1. Efficiently sequence 2-to-8 units on the same system to meet load requirement.

2. Integrated control and wiring for seamless installation of optional isolation valve.
When valves are utilized, the system shall operate one motorized valve per unit
as an element of load sequencing. Valves shall close with decreased load as
units turn off, minimum of one must always stay open for recirculation.
3. Automatically rotate lead/lag amongst the units on the chain and monitor run hours per unit and balance load in an effort to equalize unit run hours.

4. Designated master control, used to display and adjust key system parameters.

5. Automatic bump-less transfer of master function to next unit on the chain in case of designated master unit failure; master/slave status should be shown on the individual unit displays.

6. Designated master control, used to display and adjust key system parameters.

K. Building Automation System Interface: Hardware and software to enable building automation system (BAS) to monitor, control, and display boiler status and alarms.

1. Hardwired Contacts:
   a. Monitoring: Boiler Status, Burner Demand, General Alarm, Firing Rate.
   b. Control with Factory Installed Jumper: Safety Interlock for External Device, Remote Boiler Enable, Remote Lead/Lag Enable, Emergency Stop (E-Stop)
   c. Remote Setpoint Signal: 4-20 mA.

2. Communication Protocol: A communication interface with BAS shall enable BAS operator to remotely enable and monitor the boiler plant from an operator workstation.
   a. The boilers will communicate with each other and the Building Automation System via a daisy chain addressed Modbus network. Field wiring between nodes shall be twisted pair low voltage with shielded ground.

2.04 ELECTRICAL POWER

A. Controllers, Electrical Devices and Wiring: Electrical devices and connections are specified in Division 26 sections.

B. Single-Point Field Power Connection: Factory-installed and factory-wired switches, motor controllers, transformers and other electrical devices shall provide a single-point field power connection to the boiler.

C. Electrical Characteristics:

1. Voltage: 120 V
2. Phase: Single
3. Frequency: 60 Hz
4. Full-Load Current 13 Amps
2.05 VENTING
A. The exhaust vent must be UL Listed for use with Category II, III and IV appliances and compatible with operating temperatures up to 230°F, positive pressure, condensing flue gas service. UL-listed vents shall be AL 29-4C or 316L stainless steel.
B. Combustion-Air Intake: Boilers shall be capable of drawing combustion air from the outdoors via a metal or PVC duct connected between the boiler and the outdoors.
C. The minimum sealed combustion air duct size for each boiler is six-inch diameter.
D. Follow guidelines specified in manufacturer’s venting guide.

2.06 SOURCE QUALITY CONTROL
A. Burner and Hydrostatic Test: Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions and carbon monoxide in flue gas, and to achieve combustion efficiency. Perform hydrostatic testing.
B. Test and inspect factory-assembled boilers, before shipping, according to ASME Boiler and Pressure Vessel Code.
   1. If boilers are not factory assembled and fire-tested, the local vendor is responsible for all field assembly and testing.
C. Allow Owner access to source quality-control testing of boilers. Notify Architect fourteen days in advance of testing.

2.07 ACCESSORIES
A. Provide neutralizing tank and kit for each boiler to collect and neutralize flue condensate discharge from both boilers.

PART 3 - EXECUTION
3.01 INSTALLATION
A. Before boiler installation, examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations. Examine piping and electrical connections to verify actual locations, sizes and other conditions affecting boiler performance, maintenance and operations.
   1. Final boiler locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.
B. Examine mechanical spaces for suitable conditions where boilers will be installed.
C. Proceed with installation only after unsatisfactory conditions have been corrected.
3.02 BOILER INSTALLATION

A. Install boilers level on existing concrete bases.
B. Install gas-fired boilers according to NFPA 54.
C. Assemble and install boiler trim.
D. Install electrical devices furnished with boiler but not specified to be factory mounted.
E. Install control wiring to field-mounted electrical devices.

3.03 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 sections. Drawings indicate general arrangement of piping, fittings and specialties.
B. Install piping adjacent to boiler to permit service and maintenance.
C. Install piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection. Provide an isolation valve if required.
D. Connect gas piping to boiler gas-train inlet with unions. Piping shall be at least full size of gas train connection. Provide a reducer if required.
E. Connect hot-water piping to supply and return boiler tappings with shutoff valve and union or flange at each connection.
F. Install piping from safety relief valves to nearest floor drain.
G. Boiler Venting
   1. Install flue venting kit and combustion-air intake.
   2. Connect venting full size to boiler connections. Comply with requirements in Division 15 Section "Breechings, Chimneys and Stacks."
H. Ground equipment according to Division 16 Section "Grounding and Bonding for Electrical Systems."
I. Connect wiring according to Division 16 Section "Low-Voltage Electrical Power Conductors and Cables."

3.04 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.
   1. After boiler installation is completed, the manufacturer shall provide the services of a field representative to inspect components, assemblies, and equipment
installations, including connections and provide startup of the boiler and training to the operator.

2. Arrange with National Board of Boiler and Pressure Vessel Inspectors for inspection of boilers and piping. Obtain certification for completed boiler units, deliver to Owner, and obtain receipt.

B. Tests and inspections:

1. Perform installation and startup checks according to manufacturer’s written instructions.

2. Leak Test: Hydrostatic test. Repair leaks and retest until no leaks exist.

3. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.
   a. Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level and water temperature.
   b. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

4. Control and safeties: Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace malfunctioning units and retest as specified above.

D. Occupancy Adjustments: When requested within 12 months of startup, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to 2 visits to Project during other than normal occupancy hours for this purpose.

3.05 CLEANING AND FLUSHING

A. After the boiler has been installed, the Subcontractor shall boil out the boiler and the entire piping system at low pressure for a period of not less than 8 hours by recirculating a solution consisting of 4 lb (2 kg) trisodium phosphate for each 1000 lb (454 kg) of water contained in the system. After boiling out, the boiler and system shall be drained and thoroughly flushed and immediately refilled with clean water and drained again. Finally, refill immediately to normal operating level with clean, chemically treated soft water, approved by District Representative, before placing into service.

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY
A. Section includes design, performance criteria, refrigerants, controls, and installation requirements for air-cooled scroll compressor chillers.

1.02 REFERENCES
A. Comply with applicable Standards/Codes of AHRI 550/590, ANSI/ASHRAE 15, ETL, cETL, NEC, and OSHA as adopted by the State.
B. Units shall meet the efficiency standards of the current version of ASHRAE Standard 90.1, and FEMP standard 2012.

1.03 SUBMITTALS
A. Submit shop drawings and product data in accordance with the specifications.
B. Submittals shall include the following:
   1. Dimensioned plan and elevation view drawings, required clearances, and location of all field connections.
   2. Summary of all auxiliary utility requirements such as electricity, water, etc. Summary shall indicate quality and quantity of each required utility.
   3. Single line schematic drawing of the field power hookup requirements, indicating all items that are furnished.
   4. Schematic diagram of control system indicating points for field interface/connection.
   5. Diagram shall fully delineate field and factory wiring.
   6. Installation and operating manuals.

1.04 QUALITY ASSURANCE
A. Qualifications: Equipment manufacturer must specialize in the manufacture of the products specified and have five years’ experience with the type of equipment and refrigerant offered.
B. Regulatory Requirements: Comply with the codes and standards specified.
1.05 DELIVERY AND HANDLING

A. Chiller shall be delivered to the job site completely assembled and charged with refrigerant and oil by the manufacturer.

B. Comply with the manufacturer’s instructions for rigging and handling equipment.

1.06 WARRANTY

A. Standard Warranty (Domestic): The refrigeration equipment manufacturer’s guarantee shall be for a period of one year from date of equipment start-up but not more than 18 months from shipment. The guarantee shall provide for repair or replacement due to failure by material and workmanship that prove defective within the above period, excluding refrigerant.

B. 1st Year Labor Warranty: None included

C. Extended Unit Warranty: 5 year parts and labor

D. Refrigerant Warranty: None.

E. Delay Warranty Start: None.

1.07 MAINTENANCE

A. Maintenance of the chillers shall be the responsibility of the owner and performed in accordance with the manufacturer’s instructions.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Carrier

B. Daikin Applied

C. Or equal

2.02 UNIT DESCRIPTION

A. Provide and install as shown on the plans factory-assembled, factory-charged air-cooled scroll compressor packaged chillers in the quantity specified. Each chiller shall consist of hermetic tandem scroll compressor sets (total four compressors), brazed plate evaporator, air-cooled condenser section, microprocessor-based control system and all components necessary for controlled unit operation.

B. Each chiller shall be factory run-tested to verify operation. Operating controls and refrigerant charge shall be checked for proper operation and optimum performance.
2.03 DESIGN REQUIREMENTS

A. Flow Range: The chiller shall have the ability to support variable flow range down to 40% of nominal design (based on AHRI conditions).

B. Operating Range: The chiller shall have the ability to control leaving chilled fluid temperature from 15°F to 65°F.

C. General: Provide a complete scroll compressor packaged chiller as specified herein and as shown on the drawings. The unit shall be in accordance with the standards referenced in section 1.02 and any local codes in effect.

D. Performance: Refer to the schedule of performance on the drawings. The chiller shall be capable of stable operation to a minimum percentage of full load (without hot gas bypass) of 25%. Performance shall be in accordance with AHRI Standard 550/590.

E. Acoustics: Sound pressure levels for the unit shall not exceed the following specified levels (without insulation). All manufacturers shall provide the necessary sound treatment (parts and labor) to meet these levels if required. Sound data shall be provided with the quotation. Test shall be in accordance with AHRI Standard 370.

<table>
<thead>
<tr>
<th>Sound Pressure (at 30 feet)</th>
<th>63 Hz</th>
<th>125 Hz</th>
<th>250 Hz</th>
<th>500 Hz</th>
<th>1000 Hz</th>
<th>2000 Hz</th>
<th>4000 Hz</th>
<th>8000 Hz</th>
<th>Overall dBA</th>
<th>75% Load dBA</th>
<th>50% Load dBA</th>
<th>25% Load dBA</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>68</td>
<td>68</td>
<td>67</td>
<td>62</td>
<td>60</td>
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<td>49</td>
<td>44</td>
<td>65</td>
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<tr>
<td>Sound Power</td>
<td>63 Hz</td>
<td>125 Hz</td>
<td>250 Hz</td>
<td>500 Hz</td>
<td>1000 Hz</td>
<td>2000 Hz</td>
<td>4000 Hz</td>
<td>8000 Hz</td>
<td>Overall dBA</td>
<td>75% Load dBA</td>
<td>50% Load dBA</td>
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<td></td>
<td>95</td>
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<td>89</td>
<td>87</td>
<td>81</td>
<td>76</td>
<td>71</td>
<td>92</td>
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</tbody>
</table>

2.04 CHILLER COMPONENTS

A. Compressor

1. The compressors shall be sealed hermetic, scroll type with crankcase oil heater and suction strainer. The compressor motor shall be refrigerant gas cooled, high torque, hermetic induction type, and two-pole, with inherent thermal protection on all three phases and shall be mounted on RIS vibration isolator pads. The compressors shall be equipped with an internal module providing compressor protection and communication capability.

B. Evaporator

1. The evaporator shall be a compact, high efficiency, dual circuit, brazed plate-to-plate type heat exchanger consisting of parallel stainless steel plates.

2. The evaporator shall be protected with an electric resistance heater (heat trace tape) and insulated with 3/4" (19mm) thick closed-cell polyurethane insulation. This combination shall provide freeze protection down to -20°F (-29°C) ambient air temperature.
3. The water-side working pressure shall be a minimum of 653 psig (4502 kPa). Evaporators shall be designed and constructed according to, and listed by, Underwriters Laboratories (UL).

C. Condenser

1. Condenser fans shall be propeller type arranged for vertical air discharge and individually driven by direct-drive fan motors. The fans shall be equipped with a heavy-gauge vinyl-coated fan guard. Fan motors shall be TEAO type with permanently lubricated ball bearings, inherent overload protection, three-phase, direct-drive, and 1140 rpm. Each fan section shall be partitioned to avoid cross circulation.

2. Coil shall be all aluminum alloy microchannel design and shall have a series of flat tubes containing multiple, parallel flow microchannels layered between the refrigerant manifolds. Coils shall consist of a two-pass arrangement. Each condenser coil shall be factory leak tested with high-pressure air under water. Condenser coils shall include ElectroFin™ baked epoxy coating providing 5000+ hour salt spray resistance (ASTM B117-90) applied to both the coil and the coil frames.

D. Refrigerant Circuit

1. Each of the two refrigerant circuits shall include a refrigerant filter-drier, sight glass with moisture indicator, liquid line solenoid valve (no exceptions), expansion valve, and insulated suction line.

E. Construction

1. Unit casing and all structural members and rails shall be fabricated of pre-painted or galvanized steel to meet ASTM B117, 500-hour salt spray test.

2. Upper condenser coil section of unit shall have protective, 12 GA, PVC-coated, wire grille guards.

F. Control System

1. A centrally located weatherproof control panel shall contain the field power connection points, control interlock terminals, and control system. Power and starting components shall include factory circuit breaker for fan motors and control circuit, individual contactors for each fan motor, solid-state compressor three-phase motor overload protection, inherent fan motor overload protection and two power blocks (one per circuit) for connection to remote, Design Builder supplied disconnect switches. Hinged access doors shall be lockable. Barrier panels or separate enclosures are required to protect against accidental contact with line voltage when accessing the control system.

2. Shall include optional single-point connection to a non-fused disconnect switch with through-the-door handle and compressor circuit breakers.

G. Unit Controller
1. An advanced DDC microprocessor unit controller with a 5-line by 22-character liquid crystal display provides the operating and protection functions. The controller shall take preemptive limiting action in case of high discharge pressure or low evaporator pressure. The controller shall contain the following features as a minimum:

2. The unit shall be protected in two ways: (1) by alarms that shut the unit down and require manual reset to restore unit operation and (2) by limit alarms that reduce unit operation in response to some out-of-limit condition. Shut down alarms shall activate an alarm signal.

3. Shutdown Alarms
   a. No evaporator water flow (auto-restart)
   b. Sensor failures
   c. Low evaporator pressure
   d. Evaporator freeze protection
   e. High condenser pressure
   f. Outside ambient temperature (auto-restart)
   g. Motor protection system
   h. Phase voltage protection (Optional)

4. Limit Alarms
   a. Condenser pressure stage down unloads unit at high discharge pressures.
   b. Low ambient lockout shuts off unit at low ambient temperatures.
   c. Low evaporator pressure hold, holds stage #1 until pressure rises.
   d. Low evaporator pressure unload, shuts off one compressor.

5. Unit Enable Section
   a. Enables unit operation from either local keypad, digital input, or BAS

6. Unit Mode Selection
   a. Selects standard cooling, or test operation mode

7. Analog Inputs:
a. Reset of leaving water temperature, 4-20 mA\n
b. Current Limit

8. Digital Inputs

a. Unit off switch
b. Remote start/stop
c. Flow switch
d. Motor protection

9. Digital Outputs

a. Shutdown alarm; field wired, activates on an alarm condition, off when alarm is cleared
b. Evaporator pump; field wired, starts pump when unit is set to start

10. Condenser fan control - The unit controller shall provide control of condenser fans based on compressor discharge pressure.

11. Building Automation System (BAS) Interface

a. Factory mounted DDC controller(s) shall support operation on a BACnet®, Modbus® or LONMARK® network via one of the data link / physical layers listed below as specified by the successful Building Automation System (BAS) supplier.

b. BACnet MS/TP master (Clause 9)
c. BACnet IP, (Annex J)
d. BACnet ISO 8802-3, (Ethernet)
e. LONMARK FTT-10A. The unit controller shall be LONMARK® certified.

f. The information communicated between the BAS and the factory mounted unit controllers shall include the reading and writing of data to allow unit monitoring, control and alarm notification as specified in the unit sequence of operation and the unit points list.

g. All communication from the chiller unit controller as specified in the points list shall be via standard BACnet objects. Proprietary BACnet objects shall not be allowed. BACnet communications shall conform to the BACnet protocol (ANSI/ASHRAE135-2001). A BACnet Protocol Implementation Conformance Statement (PICS) shall be provided along with the unit submittal.
h. BAS interface shall be compatible with the existing building DDC system (Tracer by Trane).

2.05 OPTIONS AND ACCESSORIES

A. The following options are to be included:

1. Hot Gas Bypass: Allows unit operation to 10 percent of full load. Includes factory-mounted hot gas bypass valve, solenoid valve, and manual shutoff valve for each circuit.

2. Low Ambient Control: Provide fan cycling control to allow unit operation down to 32°F

3. BAS interface module to provide interface with the BACnet MSTP protocol.

4. The following accessories, if selected, are to be included:

   a. Field-mounted, paddle type, chilled water flow switch field wired to the control panel

   b. Wye strainer, to be installed at the evaporator inlet and sized for the design flow rate, with perforation diameter of 0.063” (for Brazed Plate evaporators) or 0.125” (for Shell-and-Tube evaporators) with blowdown valve and Victaulic couplings (factory mounted or field installed).

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install in strict accordance with manufacturer’s requirements, shop drawings, and contract documents.

B. Adjust and level chiller in alignment on supports.

C. Coordinate electrical installation with electrical Design Builder.

D. Coordinate controls with control Design Builder.

E. Install a field-supplied or optional manufacturer-supplied strainer in the chilled water return line at the evaporator inlet; 40-mesh on units with brazed-plate evaporators.

3.02 START-UP

A. Provide testing and starting of machine, and instruct the Owner in its proper operation and maintenance.

END OF SECTION
SECTION 23 64 03

PACKAGED AIR COOLED CHILLER – LARGER THAN 60 TON
(SCROLL COMPRESSOR)

PART 1 - GENERAL

1.01 DESCRIPTION

A. Scroll compressor type air-cooled chillers complete with accessories.

1.02 RELATED WORK

A. Agreement for Mechanical and Control Design-Build Project
B. Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION.
C. Section 23 21 23, HYDRONIC PUMPS.
D. Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT.
E. Section 23 21 13, HYDRONIC PIPING.
F. Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC and STEAM GENERATION EQUIPMENT.
G. Section 26 29 11, LOW-VOLTAGE MOTOR STARTERS.
H. Agreement for Mechanical and Control Design-Build Project, GENERAL COMMISSIONING REQUIREMENTS
I. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS: Requirements for commissioning, systems readiness checklists, and training.

1.03 DEFINITION

A. Engineering Control Center (ECC): The centralized control point for the intelligent control network. The ECC comprises of personal computer and connected devices to form a single workstation.
C. Ethernet: A trademark for a system for exchanging messages between computers on a local area network using coaxial, fiber optic, or twisted-pair cables.
1.04 QUALITY ASSURANCE

A. Refer to Paragraph, QUALITY ASSURANCE, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION, and comply with the following.

B. Refer to PART 3 herein after and Section 01 00 00, GENERAL REQUIREMENTS for test performance.

C. Comply with AHRI requirements for testing and certification of the chillers.

D. Refer to paragraph, WARRANTY, Section 00 72 00, GENERAL CONDITIONS, except as noted below:

1. Provide a 5-year motor, //transmission,// and compressor warranty to include materials, parts and labor.

E. Refer to OSHA 29 CFR 1910.95(a) and (b) for Occupational Noise Exposure Standard

F. Refer to ASHRAE Standard 15, Safety Standard for Refrigeration System, for refrigerant vapor detectors and monitor.

1.05 APPLICABLE PUBLICATIONS

A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.

B. Air Conditioning, Heating and Refrigeration Institute (AHRI):

370-01 ....................... Sound Rating of Large Outdoor Refrigerating and Air-Conditioning Equipment

495-1999 (R2002) .......... Refrigerant Liquid Receivers

550/590-03 .................. Standard for Water Chilling Packages Using the Vapor Compression Cycle

560-00 ........................ Absorption Water Chilling and Water Heating Packages

575-94 ........................ Methods for Measuring Machinery Sound within Equipment Space

C. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE):


D. American Society of Mechanical Engineers (ASME):
2007 .......................... ASME Boiler and Pressure Vessel Code, Section VIII, "Pressure Vessels - Agreement for Mechanical and Control Design-Build Project"

E. American Society of Testing Materials (ASTM):
   C 534/ C 534M-2008.....Preformed, Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form
   C 612-04 .................. Mineral-fiber Block and Board Thermal Insulation

F. National Electrical Manufacturing Association (NEMA):
   250-2008 .................. Enclosures for Electrical Equipment (1000 Volts Maximum)

G. National Fire Protection Association (NFPA):
   70-2008 .................. National Electrical Code

H. Underwriters Laboratories, Inc. (UL):
   1995-2005 .............. Heating and Cooling Equipment

1.06 SUBMITTALS

A. Submit in accordance with Specification Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.

B. Manufacturer's Literature and Data.

1. Centrifugal air chillers, including variable frequency drives and control panels shall include the following:

   a. Rated capacity.
   b. Pressure drop.
   c. Efficiency at full load and part load WITHOUT applying any tolerance indicated in the AHRI 550/590/Standard.
   d. Refrigerant
   e. Fan performance
   f. Accessories.
   g. Installation instructions.
   h. Startup procedures.
   i. Wiring diagrams, including factor-installed and field-installed wiring.
j. Sound/Noise data report. Manufacturer shall provide sound ratings. Noise warning labels shall be posted on equipment.

C. Maintenance and operating manuals for each piece of equipment in accordance with Section 01 00 00, GENERAL REQUIREMENTS.

D. Run test report for all chillers.

E. Product Certificate: Signed by chiller manufacturer certifying that chillers furnished comply with AHRI requirements. The test report shall include calibrated curves, calibration records, and data sheets for the instrumentation used in factory tests.

F. Provide seismic restraints for refrigeration equipment to withstand seismic forces.

1.07 WARRANTY

A. See Agreement for Mechanical and Control Design-Build Project.

B. Provide 5 year parts and refrigerant extended warranty.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Daikin Applied

B. Trane

C. Carrier

D. Or equal

2.02 UNIT DESCRIPTION

A. Provide and install as shown on the plans factory-assembled, factory-charged air-cooled scroll compressor packaged chillers in the quantity specified. Each chiller shall consist of hermetic tandem scroll compressor sets (total four compressors), brazed plate evaporator, air-cooled condenser section, microprocessor-based control system and all components necessary for controlled unit operation.

2.03 DESIGN REQUIREMENTS

A. Flow Range: The chiller shall have the ability to support variable flow range down to 40% of nominal design (based on AHRI conditions).

B. Operating Range: The chiller shall have the ability to control leaving chilled fluid temperature from 15F to 65F.
C. General: Provide a complete scroll compressor packaged chiller as specified herein and as shown on the drawings. The unit shall be in accordance with the standards referenced in section 1.02 and any local codes in effect.

D. Performance: Refer to the schedule of performance on the drawings. The chiller shall be capable of stable operation to a minimum percentage of full load (without hot gas bypass) of 25%. Performance shall be in accordance with AHRI Standard 550/590.

E. Acoustics: Sound pressure levels for the unit shall not exceed the following specified levels. All manufacturers shall provide the necessary sound treatment (parts and labor) to meet these levels if required. Sound data shall be provided with the quotation. Test shall be in accordance with AHRI Standard 370.

<table>
<thead>
<tr>
<th>Sound Pressure (at 30 feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>63 Hz</td>
</tr>
<tr>
<td>63 Hz</td>
</tr>
</tbody>
</table>

2.04 CHILLER COMPONENTS

A. Compressor

1. The compressors shall be sealed hermetic, scroll type with crankcase oil heater and suction strainer. The compressor motor shall be refrigerant gas cooled, high torque, hermetic induction type, two-pole, with inherent thermal protection on all three phases and shall be mounted on RIS vibration isolator pads. The compressors shall be equipped with an internal module providing compressor protection and communication capability.

B. Evaporator

1. The evaporator shall be a compact, high efficiency, dual circuit, brazed plate-to-plate type heat exchanger consisting of parallel stainless steel plates.

2. The evaporator shall be protected with an external, electric resistance heater plate and insulated with 3/4" (19mm) thick closed-cell polyurethane insulation. This combination shall provide freeze protection down to -20°F (-29°C) ambient air temperature.

3. The water-side working pressure shall be a minimum of 653 psig (4502 kPa). Evaporators shall be designed and constructed according to, and listed by Underwriters Laboratories (UL).

C. Condenser
Contra Costa Community College District
Mechanical and Controls Design-Build Project

PACKAGED AIR COOLED CHILLER – LARGER THAN 60 TON
(SCROLL COMPRESSOR)

C-1129 PAC Boiler Replacement
D-1044 Campus-Wide EMS Upgrades
C-1130 PAC Chiller Replacement
D-4017 Mechanical Equipment Retrofit
C-1131 AT Packaged Unit Replacement
P-4022 AHU Replacement

1. Condenser fans shall be propeller type arranged for vertical air discharge and individually driven by direct-drive fan motors. The fans shall be equipped with a heavy-gauge vinyl-coated fan guard. Fan motors shall be TEAO type with permanently lubricated ball bearings, inherent overload protection, three-phase, direct-drive, 1140 rpm. Each fan section shall be partitioned to avoid cross circulation.

2. Coil shall be microchannel design and shall have a series of flat tubes containing multiple, parallel flow microchannels layered between the refrigerant manifolds. Tubes shall be 9153 aluminum alloy. Tubes made of 3102 alloy or other alloys of lower corrosion resistance shall not be accepted. Coils shall consist of a two-pass arrangement. Each condenser coil shall be factory leak tested with high-pressure air under water. Coils shall withstand 1000+ hour acidified synthetic sea water fog (SWAAT) test (ASTM G85-02) at 120°F (49°C) with 0% fin loss and develop no leaks.

D. Refrigerant Circuit

1. Each of the two refrigerant circuits shall include a replaceable-core refrigerant filter-drier, sight glass with moisture indicator, liquid line solenoid valve (no exceptions), expansion valve, and insulated suction line.

E. Construction

1. Unit casing and all structural members and rails shall be fabricated of pre-painted or galvanized steel. Painted parts shall be able to meet ASTM B117, 1000-hour salt spray test.

2. Upper condenser coil and base section of unit shall have protective, 12 GA, PVC-coated, wire grille guards and have painted steel wraps enclosing the coil end sections and piping.

F. Control System

1. A centrally located weatherproof control panel shall contain the field power connection points, control interlock terminals, and control system. Box shall be designed in accordance with NEMA 3R rating. Power and starting components shall include factory circuit breaker for fan motors and control circuit, individual contactors for each fan motor, solid-state compressor three-phase motor overload protection, inherent fan motor overload protection and two power blocks (one per circuit) for connection to remote, Design Builder supplied disconnect switches. Hinged access doors shall be lockable. Barrier panels or separate enclosures are required to protect against accidental contact with line voltage when accessing the control system.

2. Shall include optional single-point connection to a non-fused disconnect switch with through-the-door handle and compressor circuit breakers.

G. Unit Controller
1. An advanced DDC microprocessor unit controller with a 5-line by 22-character liquid crystal display provides the operating and protection functions. The controller shall take preemptive limiting action in case of high discharge pressure or low evaporator pressure. The controller shall contain the following features as a minimum:

2. The unit shall be protected in two ways: (1) by alarms that shut the unit down and require manual reset to restore unit operation and (2) by limit alarms that reduce unit operation in response to some out-of-limit condition. Shut down alarms shall activate an alarm signal.

3. Shutdown Alarms
   a. No evaporator water flow (auto-restart)
   b. Sensor failures
   c. Low evaporator pressure
   d. Evaporator freeze protection
   e. High condenser pressure
   f. Outside ambient temperature (auto-restart)
   g. Motor protection system
   h. Phase voltage protection (Optional)

4. Limit Alarms
   a. Condenser pressure stage down, unloads unit at high discharge pressures.
   b. Low ambient lockout, shuts off unit at low ambient temperatures.
   c. Low evaporator pressure hold, holds stage #1 until pressure rises.
   d. Low evaporator pressure unload, shuts off one compressor.

5. Unit Enable Section
   a. Enables unit operation from either local keypad, digital input, or BAS

6. Unit Mode Selection
   a. Selects standard cooling, ice, glycol, or test operation mode

7. Analog Inputs:
a. Reset of leaving water temperature, 4-20 mA
b. Current Limit

8. Digital Inputs
a. Unit off switch
b. Remote start/stop
c. Flow switch
d. Ice mode switch, converts operation and setpoints for ice production
e. Motor protection

9. Digital Outputs
a. Shutdown alarm; field wired, activates on an alarm condition, off when alarm is cleared
b. Evaporator pump; field wired, starts pump when unit is set to start

10. Condenser fan control - The unit controller shall provide control of condenser fans based on compressor discharge pressure.

11. Building Automation System (BAS) Interface
a. Factory mounted DDC controller(s) shall support operation on a BACnet®, Modbus® or LONMARK® network via one of the data link/physical layers listed below as specified by the successful Building Automation System (BAS) supplier.
b. BACnet MS/TP master (Clause 9)
c. BACnet IP, (Annex J)
d. BACnet ISO 8802-3, (Ethernet)
e. The information communicated between the BAS and the factory mounted unit controllers shall include the reading and writing of data to allow unit monitoring, control and alarm notification as specified in the unit sequence of operation and the unit points list.
f. All communication from the chiller unit controller as specified in the points list shall be via standard BACnet objects. Proprietary BACnet objects shall not be allowed. BACnet communications shall conform to the BACnet protocol (ANSI/ASHRAE135-2001). A BACnet Protocol Implementation Conformance Statement (PICS) shall be provided along with the unit submittal.
2.05 OPTIONS AND ACCESSORIES

A. The following options are to be included:

1. The following accessories, if selected, are to be included:

   a. Seismic spring vibration isolators for field installation.

   b. Field-mounted, paddle type, chilled water flow switch field wired to the control panel.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, piping and electrical to verify actual locations and sizes before chiller installation and other conditions that might affect chiller performance, maintenance, and operation. Equipment locations shown on drawings are approximate. Determine exact locations before proceeding with installation.

3.02 EQUIPMENT INSTALLATION

A. Install chiller on concrete base.

1. Concrete base is specified in Section 03 30 00, CAST-IN-PLACE CONCRETE

2. Anchor chiller to concrete base according to manufacturer’s written instructions.

3. Charge the chiller with refrigerant, if not factory charged.

4. Install accessories and any other equipment furnished loose by the manufacturer, including remote starter, remote control panel, and remote flow switches, according to the manufacturer written instructions and electrical requirements.

5. Chillers shall be installed in a manner as to provide easy access for tube pull and removal of compressor and motors etc.

B. Install thermometers and gages as recommended by the manufacturer and/or as shown on drawings.

C. Piping Connections:

1. Make piping connections to the chiller for chilled water, and other connections as necessary for proper operation and maintenance of the equipment.

2. Make equipment connections with flanges and couplings for easy removal and replacement of equipment from the equipment room.
3.03 STARTUP AND TESTING

A. Engage manufacturer’s factory-trained representative to perform startup and testing service.

B. Inspect, equipment installation, including field-assembled components, and piping and electrical connections.

C. After complete installation startup checks, according to the manufacturers written instructions, do the following to demonstrate to the VA that the equipment operate and perform as intended.

1. Check refrigerant charge is sufficient and chiller has been tested for refrigerant leak.
2. Check bearing lubrication and oil levels.
3. Verify proper motor rotation.
4. Verify pumps associated with chillers are installed and operational.
5. Verify thermometers and gages are installed.
6. Verify purge system, if installed, is functional and relief piping is routed outdoor.
7. Operate chiller for run-in-period in accordance with the manufacturer’s instruction and observe its performance.
8. Check and record refrigerant pressure, water flow, water temperature, and power consumption of the chiller.
9. Test and adjust all controls and safeties. Replace or correct all malfunctioning controls, safeties and equipment as soon as possible to avoid any delay in the use of the equipment.
10. Prepare a written report outlining the results of tests and inspections, and submit it to the VA.

D. Engage manufacturer’s certified factory trained representative to provide training for 16 hours for the VA maintenance and operational personnel to adjust, operate and maintain equipment, including self-contained breathing apparatus.

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY

A. Related Documents:
   1. Drawings and general provisions of the Subcontract apply to this Section.
   2. Review these documents for coordination with additional requirements and information that apply to work under this Section.

B. Section Includes:
   1. Design and construction of centrifugal refrigeration machine
   2. Starters with disconnect switches
   3. System control panel
   4. Refrigerant charge, oil, and like start-up materials
   5. Testing, start-up and instruction
   6. Manufacturer’s field services for start-up and instruction.
   7. Refrigeration room leak detection and monitoring system.

C. Related Sections:
   1. Agreement for Mechanical and Control Design-Build Project Section "General Requirements."
   2. Agreement for Mechanical and Control Design-Build Project Section "Special Procedures."
   3. Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."
   4. Division 23 Section "HVAC Equipment Insulation".
   5. Division 23 Section "HVAC Pumps".
   6. Division 23 Section "Induced-Draft Cooling Towers"
   7. Division 25 Section "Integrated Automation Facility Controls."
1.02 REFERENCES

A. General:

1. The following documents form part of the Specifications to the extent stated. Where differences exist between codes and standards, the one affording the greatest protection shall apply.

2. Unless otherwise noted, the referenced standard edition is the current one at the time of commencement of the Work.

3. Refer to Agreement for Mechanical and Control Design-Build Project Section "General Requirements" for the list of applicable regulatory requirements.

4. Refer to Division 23 Section "Common Results for HVAC" for codes and standards, and other general requirements.

B. Air Conditioning and Refrigeration Institute (ARI):

1. ARI 550  Centrifugal and Rotary Screw Water-Chilling Packages

2. ARI 575  Method of Measuring Machinery Sound within an Equipment Space

C. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE):

1. ASHRAE 15  Safety Code for Mechanical Refrigeration

2. ASHRAE 30  Methods of Testing Liquid Chilling Packages

D. American Society of Mechanical Engineers ASME Section VIII BPVC  Boiler and Pressure Vessel Code

E. ASTM International:

1. ASTM C 117  Test Method for Materials Finer than 75-Micrometer (No. 200) Sieve in Mineral Aggregates by Washing

2. ASTM C 335  Test Method for Steady-State Heat Transfer Properties of Horizontal Pipe Insulation

F. National Electrical Manufacturers Association (NEMA):

1. NEMA 250  Enclosures for Electrical Equipment (1000 Volt Maximum)

2. NEMA ICS 6  Enclosures for Industrial Control and Systems

G. National Fire Protection Association NFPA 70  National Electrical Code

H. National Institute of Occupational Safety and Health NIOSH TC-13F-4
I. Underwriters Laboratories, Inc. (UL)

J. 40 CFR Part 82 Protection of Stratospheric Ozone

1.03 SYSTEM DESCRIPTION

A. The refrigeration machine system shall include piping within the machine up to and including the flanged connection for chilled-water and condenser-water inlets and outlets; and control equipment and wiring within the machine, including the chilled-water and condenser pressure-differential switches, the unit-mounted variable frequency drive, auxiliary oil-pump starter and control and instrumentation devices specified.

B. Efficiency: See schedule on drawings.

C. Refrigerant: Refrigeration machine shall use HFC-134a refrigerant.

D. Acoustical Performance:
   1. Sound-pressure levels for the complete unit shall not exceed 83 dBA. Provide acoustic treatment as required.
   2. The maximum permissible noise level shall not exceed 88 dB in each octave band.
   3. Sound data shall be measured in accordance with ARI 575. Data shall be in dB, reference 0.0002 dyne/cm², measured along a perimeter 1 m from machine and at a height of 1.5 m above floor. Data shall be at the highest levels recorded in three operating positions: 100 percent load, 75 percent load, 50 percent load, and 20 percent load.

E. Compressor assembly vibration shall not exceed 1.0 mil (0.03 mm) at the bearings.

1.04 SUBMITTALS

A. Submit under provisions of Division 23 Section “Common Results for HVAC, Review of Materials and Agreement for Mechanical and Control Design-Build Project Section “General Requirements.”

B. Shop Drawings:
   1. Drawings of refrigeration machine, including dimensions prior to manufacture.
   2. Complete wiring diagrams specifically for the proposed equipment. No typical diagram will be considered. Include required wiring between unit and starter. Indicate locations of conduit connections.

C. Product Data:
   1. Refrigeration machine description and data, addressing items to be provided.
2. ARI 550 certified performance curves (kW input vs. output) for full load and non-standard part load value (NPLV). Provide performance data for chilled-water temperature conditions as applicable. In addition, provide chiller performance matrix (tons, Kw/ton, and condenser water temperature) for chiller plant energy optimization algorithm that will be implemented by Section 250000.

3. Sound-power data by octave band, at 100 percent, 75 percent, 50 percent and 20 percent of full load.

4. Refrigerant gas monitor.

D. Test Data: Certified test report as specified in subpart 2.12, “Source Quality Control.”

1.05 QUALITY ASSURANCE

PART 2 - PRODUCTS

2.01 MANUFACTURER
A. Carrier
B. Trane
C. Or equal

2.02 UNIT DESCRIPTION
A. Provide and install as shown on the plans, factory assembled, factory charged with R-134a, and factory run-tested, water-cooled, rotary screw compressor packaged chillers in the quantity and capacity specified. Each chiller shall consist of a single screw compressor, evaporator, condenser, control system and all components necessary for protected and controlled unit operation.

2.03 DESIGN REQUIREMENTS
A. General: Provide a complete rotary screw packaged chiller as specified and as shown on the drawings. The unit shall be in accordance with the standards referenced in section 1.02.
B. Performance: Refer to the schedule of performance on the drawings. The chiller system shall be capable of stable minimum part load operation without hot gas bypass.
C. Acoustics: Manufacturer must provide both sound power and sound pressure data in decibels. Sound pressure data per AHRI 575 must be provided in 8 octave band format at full load. In addition, A-weighted sound pressure at 3 feet should be provided at 100% load points to identify the full operational noise envelope. Sound power must be provided in 1/8 octave band format to highlight any tonal quality issues. If manufacturer cannot
meet the noise levels (per the attached chart), sound attenuation devices and/or barrier walls must be installed to meet this performance level.

<table>
<thead>
<tr>
<th>Octave Band</th>
<th>Overall dBA</th>
</tr>
</thead>
<tbody>
<tr>
<td>50Hz</td>
<td></td>
</tr>
<tr>
<td>125Hz</td>
<td></td>
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<tr>
<td>250Hz</td>
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<td>500Hz</td>
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<td>1kHz</td>
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<td>2kHz</td>
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<tr>
<td>4kHz</td>
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<tr>
<td>8kHz</td>
<td></td>
</tr>
<tr>
<td>16kHz</td>
<td></td>
</tr>
</tbody>
</table>

2.04 CHILLER COMPONENTS

A. Refrigerant Circuit: The unit must have a single refrigerant circuit with one compressor. The refrigerant circuit shall include an electronic expansion valve, liquid line shut-off valve, replaceable core filter-drier, and sight glass with moisture indicator.

B. Compressors:

1. Compressor Motor Control: Each compressor shall be equipped with a VFD providing compressor speed control as a function of the cooling load. Each VFD shall provide controlled motor acceleration and deceleration, and shall provide protection for the following conditions: electronic thermal overload, over/under current, stalled motor, input and output phase loss, high load current, and current unbalance. The VFD shall provide a minimum 95% compressor power factor at all load points. Compressors used in VFD controlled units must have electrically insulated, ceramic bearings to mitigate bearing and/or lubricant damage from stray electric current passage. Compressor shall be able to control compression ratio to optimize efficiency at all operating conditions. Units without this protection must have an extended 5-year compressor warranty.

2. The unit controller shall display the following data:

   a. Output Frequency
   b. Output Current
   c. Output Voltage
   d. Output Power
   e. Fault Code

3. The unit controller shall display the following alarms and faults:

   a. Over Current-Hold
   b. Over Current-Unload
   c. Over Current-Alarm
d. Overheat-Hold  
e. Overheat-Unload  
f. Overheat-Alarm  
g. Communication Fault  
h. System power not three phase  
i. Phase sequence incorrect  
j. Line frequency less than 25 Hz  
k. Line frequency more than 72 Hz  
l. Excessive current unbalance  
m. Operating parameters lost  
n. No current after “Run” command  
o. Undercurrent trip occurred  
p. Overcurrent trip occurred  
q. Control power too low  
r. Motor stalled during acceleration  
s. External fault  

4. The unit controller shall display the following operating messages:  
   a. Line voltage not present  
   b. Voltage present, starter ready  
   c. Motor accelerating  
   d. Motor at full speed  
   e. Motor at full speed, ramp time expired  
   f. Stop command received, motor decelerating  
   g. Thermal overload has reached 90% to 99%  
   h. Thermal overload at 100%, motor stopped
5. Compressor Motors: Motors shall be high torque, two pole, semi-hermetic, squirrel cage induction type with inherent thermal protection on all three phases and cooled by suction gas.

6. The compressors shall be field serviceable, semi-hermetic, single-rotor screw type with one central helical rotor meshing with two opposing gaterotors. The gaterotor contact element shall be constructed of engineered composite material, dimensionally stable up to 1500°F and wear resistant for extended life. If a twin-screw design is used, the manufacturer shall provide an extended 5-year parts and labor warranty covering all additional moving parts.

C. Evaporator and Condenser:

1. Evaporator: The evaporator shall be designed, inspected, and stamped in accordance with ASME Section VIII requirements. It shall be mounted and piped in the unit. The evaporator shall be equipped with a factory-supplied and wired flow switch.

2. The evaporator shall be flooded type with copper tubes rolled into carbon steel tubesheets. The evaporator shall have left-hand connections when looking at the unit control panel. The evaporator shall have dished heads with valved drain and vent connections. Water connections shall be grooved suitable for Victaulic couplings. The heads shall be carbon steel and the tubesheets shall be carbon steel. The waterside shall be designed for a minimum of 150psig. The wall copper tubes shall be 0.025 in.

3. The condenser shall be of the shell-and-tube type, designed, constructed, tested and stamped according to the requirements of the ASME Code, Section VIII. The tubes shall be individually replaceable and secured to the intermediate supports without rolling.

   a. The condenser shall have tubes rolled into carbon steel. The condenser shall have dished heads with valved drain and vent connections. The waterside shall be designed for a minimum of 150psig. Water connections shall be grooved suitable for Victaulic couplings. The heads shall be carbon steel and the tubesheets shall be carbon steel. The wall copper tubes shall be 0.025 in.

4. Provide sufficient condenser volume to hold the full unit refrigerant charge in the condenser during servicing or provide a separate pumpout system and storage tank sufficient to hold the charge of the largest unit being furnished.
5. Re-seating type spring loaded pressure relief valves according to ASHRAE-15 safety code shall be furnished. The condenser shall be provided with dual relief valves equipped with a transfer valve so one relief valve can be removed for testing or replacement without loss of refrigerant or removal of refrigerant from the condenser. Rupture disks are not acceptable.

6. The evaporator vessel, including water heads, suction line, and any other component or part of a component subject to condensing moisture shall be insulated with UL recognized ¾ inch (19mm) thick closed cell polyurethane insulation. All joints and seams shall be carefully sealed to form a vapor barrier.

7. Provide factory-supplied and wired, thermal-dispersion water flow switches on each vessel to prevent unit operation with no or low water flow.

D. Electrical Panel

1. 65 kA panel rating.

2. A centrally located, UL-approved weatherproof electrical control panel shall contain the unit control system, control interlock terminals and field-power connection points. Box shall be designed in accordance with NEMA 1R rating. Hinged control panel access doors shall be tool-lockable. Door mounted controller shall be provided to allow control of chiller without opening panel door.

3. The power connection shall be: Single Point and Disconnect Switch

E. Chiller Control

1. Control Section: The control logic shall be designed to maximize operating efficiency and equipment life with protections for operation under unusual conditions and to provide a history of operating conditions. The system shall intelligently stage the unit to sustain leaving water temperature precision and stability while minimizing compressor cycling.

2. Equipment protection functions controlled by the microprocessor shall include high discharge pressure, loss of refrigerant, loss of water flow, freeze protection, and low refrigerant pressure.

3. User controls shall include auto/stop switch, chilled water set-point adjustment, anti-recycle timer, and digital display with water temperature setpoint, operating temperatures and pressures, and diagnostic messages. The following features and functions shall be included:

   a. Durable liquid crystal display (LCD) screen type, having minimum four 20-character lines with 6 key input pad conveniently mounted on the unit controller. Default language and units of measure shall be English and IP respectively. Messages shall be in plain English. Coded messages, LED indicators and LED displays are not acceptable.

   b. Separate control section and password protection for critical parameters.
c. Remote reset of chilled water temperature using a 4-20mA signal.

d. Soft-load operation, protecting the compressor by preventing full-load operation during the initial chilled fluid pull-down period.

e. Non-volatile program memory allowing auto-restart after a power failure.

f. Recording of safety shutdowns, including date-and-time stamp, system temperatures and pressures. A minimum of six previous occurrences shall be maintained in a revolving memory.

g. Start-to-start and stop-to-start cycle, giving minimum compressor off time and maximizing motor protection.

h. Pro-active compressor unloading when selected operating parameters exceed design settings, such as high discharge pressure or low evaporator pressure.

i. Diagnostic monitoring of unit operation, providing a pre-alarm signal in advance of a potential shutdown, allowing time for corrective action.

4. The factory mounted controller(s) shall support operation on a network via BACnet® w/RS485 and Ethernet

   a. As specified by the successful Building Automation System (BAS) supplier. The information communicated between the BAS and the factory mounted unit controllers shall include the reading and writing of data to allow unit monitoring, control and alarm notification as specified in the unit sequence of operation and the unit points list.

2.05 OPTIONAL ITEMS

A. The following optional items shall be furnished:

B. Pumpout unit without storage vessel.

C. To ensure quick and trouble free start up and commissioning, each chiller shall pass a full battery of factory tests. These tests will include the verification of operating and compressor controls to ensure full unit functionality and manufacturing integrity. Any deviation from stringent factory quality standards shall be remedied prior to shipment.

D. Harmonic filter(s) to work in conjunction with the line reactor to further minimize harmonic distortion.

2.06 SOURCE QUALITY CONTROL

A. Submit a certified factory test report confirming performance as specified.

2.07 REFRIGERATION ROOM LEAK DETECTION AND MONITORING SYSTEM

A. General:
1. Furnish complete refrigeration emergency switches, detection and oxygen depletion monitoring system. System shall be UL listed, labeled and constructed to meet UL 508A Standard, OSHPD, CSFM and all current California Mechanical Code requirements for refrigeration monitoring, vapor evacuation and alarms per CMC Chapter 11, Section 1106, 1107, 1108 and 1120.

   a. Refrigerant Detection control and signaling components are to be UL 2017 listed, but there are no companies presently that have a UL 2017 rating for Refrigerant Detection Components. An alternative system is to send all controls and signals to the Fire Alarm System that will control and signal all life safety devices through its outputs. This system is CSFM approved.

2. The system shall be pre-wired in a NEMA 4-rated panel enclosures.

3. The system master control panel shall include but not limited to the following:

   a. Network infrared refrigerant gas sensor/monitor, 0-1000 ppm measurement range with accuracy of 3%.

   b. Network gas (oxygen) sensor/monitor, 0-25% detection range with accuracy of 3%.

   c. Gas detection controller with BACnet, datalogger, alphanumeric display keypad and four visual alarm indicators.

   d. PLC controller programmed as per sequence of operation.

   e. Switches and alarm indicators:

      1) Keyed H-O-A switches.

      2) Keyed OFF/AUTO switches.

      3) Break-glass type emergency ON and emergency OFF push buttons with manual reset. (Purge fan on and chiller/pump shutdown)

      4) Current sensing switches for supply and exhaust ducts.

      5) Push-To-Test Pilot indicator lights

      6) Strobe beacon type NEMA 4 rated visual alarms

      7) Outdoor rated audible horns, utilizing listed fire alarm signaling devices providing a sound pressure level of at least 90 db.

      8) Pull Station Switch to annunciate at 24 hours location, activate audible and visual alarm and activate auto purge and/or intermittent fans.
f. Battery Backup for the Control Panel and ALL alarming functions. 90 minutes duration.

g. Remote Notification of Alarms and Failures via Modem.

h. All wires Color Coded.

i. All UMC Codes for Refrigerant Monitoring and Control.

j. Refrigerant Level Alarming Sequence of Operation.

k. Refrigerant Level Equipment Shut Down Sequence.

4. Illuminated self-contained interior sign cabinet at the inside and outside of each door to the chiller plant room. Signage to read; Outside the door: "REFRIGERANT DISCHARGE – DO NOT ENTER". Inside the door: "REFRIGERANT DISCHARGE – EVACUATE IMMEDIATELY". Signage shall be of size and type shown in the drawings.

5. Entry remote NEMA 4-rated panel enclosure at each door. Panel shall include:

   a. Strobe beacon type NEMA 4 rated visual alarms and outdoor rated audible horns, utilizing listed fire alarm signaling devices providing a sound pressure level of at least 90 db.

   b. Break-glass type emergency on and emergency off push buttons with manual reset. (Purge fan on and chiller/pump shut-down)

   c. Pull Station Switch to annunciate at 24 hours location, activate audible and visual alarm and activate auto purge and/or intermittent fans.

6. Interior door shall include:

   a. Strobe beacon type NEMA 4 rated visual alarm and outdoor rated audible horn, utilizing listed fire alarm signaling devices providing a sound pressure level of at least 90 db. Mounting shall be above Emergency signage.

7. Self-Contained Breathing Apparatus

   a. Provide self-contained breathing apparatus (SCBA) at the entrance to each door to the mechanical room in the location indicated on the drawings. The SCBA shall be Honeywell Analytics model VA-SCBA or prior approved equal.

   b. The SCBA shall be open-circuit, positive, self-contained breathing apparatus certified by NIOSH to provide a nominal service time of (30) minutes.
c. The mask face plate shall be made of silicon with the ability to withstand 540% elongation before breaking. It shall have an external super-resistant, hard anti-scratch coating and an internal anti-fog coating.

d. The flow rate of the breathing system shall allow for 100 liters per minute in accordance with NFPA testing for “high work load”. Each tank shall be provided with a “low air” alarm.

e. The SCBA shall be housed in a wall cabinet of ABS Construction with a viewing window to allow for faster inspections and better emergency location.

B. Break-Glass Switches: Provide ASCO 124 or equal NEMA Type 3 rain tight enclosure switches which shall actuate upon breaking the glass and shall have manual reset feature, surface type labeled “CHWS Emergency Stop” and “Ventilation Emergency Start”.

C. System shall be interfaced with building management system. All field connections from the control panel to a remote device to be single point color-coded terminal type.

D. Detection and alarm systems shall be powered and supervised as required for fire alarm systems in accordance with UFC Standard 14-1. Wiring shall meet all local and national fire, building and safety codes.

E. System shall be fully calibrated for the design functions.

F. Manufacturer to be manufacturing products for minimum of 3 years.

G. System shall be American, Inc Model MRAM-09, or equal.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install per manufacturer’s IOM documentation, shop drawings, and submittal documents.

B. Align chiller on foundations or mounting rails as specified on drawings.

C. Arrange piping to enable dismantling and permit head removal for tube cleaning.

D. Coordinate electrical installation with electrical Design Builder.

E. Coordinate controls and BMS interface with controls Design Builder.

F. Provide all material required for a fully operational and functional chiller.

3.02 START-UP

A. Units shall be field charged with HFC-134a refrigerant.
B. Factory Start-Up Services: Provide factory supervised start-up on-site for a minimum of two working days to ensure proper operation of the equipment. During the period of start-up, the factory authorized technician shall instruct the owner’s representative in proper care and operation of the equipment.

3.03 SAFETY DEVICE INSTALLATION

A. Provide a legible permanent sign securely attached and accessible outside the refrigeration room entrance. Sign shall contain the following information in at least 1/2-inch (12 mm) high letters:

1. Name, address, telephone number of the installer
2. Type and quantity of refrigerant charge
3. Field test pressure
4. Instructions for shutting down the refrigeration system in an emergency
5. Name, address, and day and night telephone numbers for emergency refrigeration service
6. Name, address, and telephone number of municipal inspection authority having jurisdiction, and notification procedures in event of a refrigerant leak emergency

3.04 REFRIGERATION ROOM LEAK DETECTION AND MONITORING SYSTEM INSTALLATION

A. Install equipment, devices and wiring, according to manufacturer's written instructions, rough-in drawings, the original design, and referenced standards. Provide all of the wiring as required for a complete and functional system.

B. Electrical: Conform to applicable requirements of Division 26 Sections for connecting electrical equipment.

C. Install electrical devices furnished, but not specified to be factory mounted.

D. Test all of the sensors with simulating the sensors operation and calibrate the sensors.

E. Test the alarm devices.

F. Test all of the system functions.

3.05 FIELD QUALITY CONTROL

A. Manufacturer’s Field Services:

1. Provide service of a factory-trained service engineer to supervise testing, evacuation, hydration, charging of unit, and start-up; make necessary adjustments; and instruct the District’s operator on the care, operation and maintenance of the system.
2. Provide five 8-hour days of service for the first unit, and two 8-hour days for each additional unit.

B. Notify the District at least 24 hours in advance of field tests to allow District Representative to witness the tests.

C. Operational Control Tests:

1. Demonstrate proper functioning of the entire operational control of the chiller. Verify proper operation as specified in Part 2 of this section, including oil pumps, liquid-line solenoid valves, crankcase heaters, thermal-expansion valves, chilled-water and condenser waterflow switches, and adjustable temperature controllers.

2. Demonstrate chiller capacity control by varying the chiller load. The capacity range to be tested shall be from no-load to full-load and back to no-load. The chiller shall demonstrate stable operation without excess vibration or noise. Verify each step of the multi-step control (cylinder unloading and/or compressor staging).

D. Safety Control Tests:

1. Demonstrate proper functioning of safety cutouts in accordance with safety control requirements of Part 2 of this section.

2. Demonstrate that manual resetting is required to restart compressors for safety cutouts.

3. Demonstrate proper operation of interlocking between chillers and condenser-water pumps, and between chillers and chilled-water pumps.

4. Simulate variables to activate safety control actions.

5. All safety control tests shall be verified by electric signals at the compressor motor starters or actual stopping of the compressors.

E. Running and Warning Indicators Test:

1. Demonstrate proper functioning of indicating lights.

2. Testing of running and warning indicators may be performed concurrently with safety control tests.

F. Field Tests:

1. Pressure Test: After assembly of the complete unit on the job, pressure test the unit with a mixture of refrigerant and air, and test connections and welds with an electronic leak-detector torch and make refrigerant-tight. The complete unit shall be dehydrated by producing a vacuum to 0.3 inch (7.6 mm) Hg absolute and maintained for four hours. At the end of this period, stop the pump. The vacuum shall be maintained in the refrigeration unit for a period of 24 hours without gaining more than 0.1 inch (2.5 mm) Hg absolute pressure.
2. Provide sufficient refrigerant and dry nitrogen for pressure testing under manufacturer’s supervision.

3. Provide instruments required for conducting tests.

3.06 DEMONSTRATION AND TRAINING

A. Schedule operation and maintenance instruction period with the District Representative. Submit operation and maintenance manuals in advance of instruction period. Provide manuals for the training of 6 personnel.

B. Training shall be conducted by the factory authorized instructor. Submit the instructor’s resume for review.

END OF SECTION
PART 1 - GENERAL

1.01 WORK INCLUDED
A. Cooling towers.
B. Filtration systems.

1.02 RELATED WORK
A. Section 23 05 00 – Common Results for HVAC
B. Section 23 05 12 – General Motor Requirements for HVAC and Steam Generation Equipment
C. Section 23 05 48 – Vibration and Seismic Controls for HVAC System and Equipment
D. Section 23 05 93 – Testing Adjusting and Balancing for HVAC
E. Section 23 21 13 – Hydronic Piping
F. Section 23 21 20 – Hydronic Specialties
G. Section 23 25 00 – HVAC Water Treatment
H. Section 23 64 05 – Packaged Water Cooled Chiller (Centrifugal)

1.03 SUBMITTALS
Comply with all of the following:
A. Section 230500 and Agreement for Mechanical and Control Design-Build Project.
B. Submit suggested structural-steel support including dimensions, sizes, and locations for mounting bolt holes. Include weight-distribution drawings, showing point loadings.
C. Submit schematic showing capacity controls.
D. Submit manufacturers’ installation, operation, and maintenance instructions.

1.04 WARRANTY
A. Submit a written warranty executed by the manufacturer, agreeing to repair or replace components of the unit that fail in materials and workmanship within the specified warranty period.
1. The Entire Unit shall have a comprehensive one (1) year warranty against defects in materials and workmanship from startup, not to exceed eighteen (18) month from shipment of the unit.

2. Fan Motor/Drive System: Warranty Period shall be Five (5) years from date of unit shipment from Factory (fan motor(s), fan(s), bearings, mechanical support, sheaves, bushings and belt(s)).

1.05 DELIVERY

A. Factory-assemble entire unit. For shipping, disassemble into as large as practical subassemblies so that minimum amount of field work is required for reassembly.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS – COOLING TOWER

A. EVAPCO model AT, BAC, or Marley. Type 304 Stainless Steel Construction.

B. Or approved equal.

C. Design Builder is responsible for all design, engineering, documentations, plan-check, structural provision, electrical, and plumbing provision if other manufacturer other than the basis of design is submitted.

2.02 ARRANGEMENT

A. Cooling tower shall fit the existing space without decrease in performance.

2.03 COMPONENTS

A. Description: Factory assembled and tested, induced draft counter flow cooling tower complete with fan, fill, louvers, accessories and rigging supports.

B. Materials of Construction

1. All cold water basin components including vertical supports, air inlet louver frames and panels up to rigging seam shall be constructed of heavy gauge Type 304 stainless steel.

2. Upper Casing, channels and angle supports shall be constructed of heavy gauge type 304 stainless steel. Fan cowl and guard shall be constructed of stainless steel.

C. Fan(s):

1. Fan(s) shall be high efficiency axial propeller type with aluminum wide chord blade construction. Each fan shall be dynamically balanced and installed in a closely fitted cowl with venturi air inlet for maximum fan efficiency.
D. Drift Eliminators:
   1. Drift eliminators shall be constructed entirely of Polyvinyl Chloride (PVC) in easily handled sections. Design shall incorporate three changes in air direction and limit the water carryover to a maximum of 0.001% of the recirculating water rate.

E. Water Distribution System:
   1. Spray nozzles shall be precision molded ABS, large orifice nozzles utilizing fluidic technology for superior water distribution over the fill media. Nozzles shall be designed to minimize water distribution system maintenance. Spray header and branches shall be Schedule 40 Polyvinyl Chloride (PVC) for corrosion resistance with a steel connection to attach external piping.

F. Heat Transfer Media
   1. Fill media shall be constructed of Polyvinyl Chloride (PVC) of cross-fluted design and suitable for inlet water temperatures up to 130° F. The bonded block fill shall be bottom supported and suitable as an internal working platform. Fill shall be self-extinguishing, have a flame spread of 5 under A.S.T.M. designation E-84-81a, and shall be resistant to rot, decay and biological attack.

G. Air Inlet Louvers
   1. The air inlet louver screens shall be constructed from UV inhibited polyvinyl chloride (PVC) and incorporate a framed interlocking design that allows for easy removal of louver screens for access to the entire basin area for maintenance. The louver screens shall have a minimum of two changes in air direction and shall be of a non-planar design to prevent splash-out and block direct sunlight & debris from entering the basin.

H. Electronic Water Level Control
   1. Electronic water level control package shall have five (5) stainless steel water level sensors (one (1) high level, one (1) high level alarm, one (1) low level, one (1) low level alarm and one (1) ground) with a NEMA 4x enclosure mounted in a cleanable Schedule 40 PVC external standpipe with slow closing solenoid valve(s) and "Y" strainer(s). Wiring is not included and components must be field mounted. Valves shall be sized for 25 psi minimum to 125 psi maximum pressure. Standpipe may require heat tracing by others in cold weather applications.

I. Pan Strainer
   1. Pan Strainer(s) shall be all Type 304 Stainless Steel construction with large area removable perforated screens.

2.04 MOTORS AND DRIVES

A. General requirements for motors are specified in Division 23 Section “Motors”. 
B. Fan Motor

1. Fan motor(s) shall be totally enclosed, ball bearing type electric motor(s) suitable for moist air service. Motor(s) are Premium Efficient, Class F insulated, 1.15 service factor design. Inverter rated per NEMA MG1 Part 31.4.4.2 and suitable for variable torque applications and constant torque speed range with properly sized and adjusted variable frequency drives.

2. Fan motor(s) shall include strip-type space heaters with separate leads brought to the motor conduit box.

C. Fan Drive

1. The fan drive shall be multigroove, solid back V-belt type with QD tapered bushings designed for 150% of the motor nameplate power. The belt material shall be neoprene reinforced with polyester cord and specifically designed for evaporative equipment service. Fan sheave shall be aluminum alloy construction. Belt adjustment shall be accomplished from the exterior of the unit.

D. Fan Shaft

1. Fan shaft shall be solid, ground and polished steel. Exposed surface shall be coated with rust preventative.

E. Fan Shaft Bearings

1. Fan Shaft Bearings shall be heavy-duty, self-aligning ball type bearings with extended lubrication lines to grease fittings located on access door frame. Bearings shall be designed for a minimum L-10 life of 100,000 hours.

F. Vibration Switch

1. Unit shall be provided with a Vibration Cutout Switch, operating on 120 VAC feed, to protect the fan and drive assembly from damage in the event of excess vibration. Vibration switch shall be DPDT.

2.05 MAINTENANCE ACCESS

A. Fan Section

1. Access door shall be hinged and located in the fan section for fan drive and water distribution system access. Swing away motor cover shall be hinged for motor access.

B. Basin Section

1. Framed removable louver panels shall be on all four (4) sides of the unit for pan and sump access.

C. Internal Working Platform
1. Internal working platform shall provide easy access to the fans, belts, motors, sheaves, bearings, all mechanical equipment and complete water distribution system. The fill shall be an acceptable means of accessing these components.

D. Ladder

1. An aluminum sloped ladder shall be provided for access to the motor access door.

2.06 ACCEPTABLE MANUFACTURERS – BASIN CLEANER

A. LAKOS TC, PEP, Yardney,

B. Or equal

2.07 BASIN CLEANER

A. The basin cleaner shall be a factory assembled package specifically designed for cleaning and filtering cooling tower basins.

B. The system shall consist of:

1. Skid-mounted pump with inlet basket strainer, centrifugal separator, solids collection vessel with purge/return line, valved inlet and outlet, and electrical/control panel.

2. Cooling tower basin installed piping with sweeper eductors, basing suction/collection pipe and all external interconnecting piping required.

C. Components


2. Enamel paint on all components.

3. Lakos centrifugal separator.

4. End suction TEFC motor with specified efficiency, per Section 15170 - Motors.

5. Pump inlet basket strainer with ¼ inch mesh screen and isolation valve.


7. Schedule 40 black steel piping.

8. Nylon reinforced rubber hose to collection vessel.

9. Ball valves at system inlet and outlet.
10. Automatic purge valve and manual ball valve at collection vessel discharge.

11. Controls including pressure gauges, pressure sensor and indicator for collection vessel servicing, interlock contact for remote start/stop control (unit to operate only when at least one cooling tower operates and there is water in the system), and contact for remote monitoring (by the Facilities Monitoring and Control System) for collection vessel servicing.

12. Electrical to include heavy-duty NEMA-rated combination starter (per Section 16481) with HOA switch, heaters, fused disconnect, overload reset, and NEMA 4X enclosure.

13. Provide all required piping and eductor nozzles for each cooling tower basin for complete and effective sweeping to the pump intake. Utilize 304 stainless steel piping or optionally, Schedule 80 PVC socket-welded piping if allowed by FM approval. The manufacturer will provide design services to select basin piping and eductor sizing and layouts.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Before installation, verify that support structure is sound, level, and properly dimensioned. Verify all dimensions in the field. Beginning of installation means acceptance of the structural conditions.

3.02 COOLING TOWER

A. Install and support per manufacturer's recommendations and to meet UBC seismic requirements.

B. Set level with plus or minus 1/4” between any two points on distribution basin.

C. Before operation of the cooling tower verify that the tower is clean, sound, level, vibration free and operable in every respect.

D. Supervise all piping and wiring connections to cooling tower. Verify correctness of all wiring. Return to the job site as necessary to accomplish this work.

E. Before operation of the cooling tower, verify that the water treatment system and the basin cleaner system are in operation.

F. Adjust fan blade pitch and water distribution to meet scheduled performance.

3.03 BASIN CLEANER

A. Install the filter assembly per manufacturer's recommendations.

B. Install connecting piping to and from both cooling towers per manufacturer's recommendations.
3.04 MAINTENANCE AND OPERATING AND TRAINING INSTRUCTIONS

A. Agreement for Mechanical and Control Design-Build Project.

END OF SECTION
PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Dual duct, dual fan air handling units with relief fans and economizer dampers.

B. Filters
   1. Pre-filters

1.02 RELATED DOCUMENTS

A. Section 23 05 00 – Common Results for HVAC

B. Section 23 05 12 – General Motor Requirements for HVAC and Steam Generation Equipment

C. Section 23 05 48 – Vibration and Seismic Controls for HVAC System and Equipment

D. Section 23 05 93 – Testing Adjusting and Balancing for HVAC

E. Section 23 29 23 – Variable Frequency Drives

F. Section 23 31 13 – Metal Ducts

G. Section 23 34 16 – Centrifugal HVAC Fans

1.03 SUBMITTALS

A. Submit in accordance with Agreement for Mechanical and Control Design-Build Project and Section 23 05 00 – Common Work results for Mechanical.
   1. Air Handlers: Construction, features, dimensions, shipping sections, field joints, weight, certified performance, sound power levels at cabinet inlet and outlet and cabinet radiation, anticipated factory test dates, and factory test result reports.
      a. Provide plans and elevations at minimum ¼” scale.
   2. Pre-filters.

1.04 OPERATION AND MAINTENANCE DATA

A. Submit in accordance with Agreement for Mechanical and Control Design-Build Project and Section 23 05 00 – Common Work results for Mechanical.
1. A detailed description of the operating system, its components, and principals of operation.

2. Startup and service procedures and checklists.

3. Relevant data such as bill of materials, parts list, drawings, etc. Where necessary, manuals shall include exploded diagrams of relevant equipment to provide sufficient detail and clarity with which to identify replacement parts.

4. Assembly and disassembly instructions for parts replacement or servicing requirements.

5. Recommended spare parts list with current prices, including sizes of fan belts and filters.

6. Preventative maintenance and lubrication schedules.

7. Troubleshooting procedures.

8. List of telephone numbers of local service organizations.


10. Final copy of factory test reports.

PART 2 - PRODUCTS

2.01 CUSTOM-BUILT AIR HANDLERS

A. Manufacturers:

1. HuntAir FanWall, ClimateCraft, or equal

2.02 ROOF TOP AIR HANDLING UNIT

A. Manufacturers:

1. Huntair, Temtrol, ClimateCraft, or approved equal.

B. Arrangement: As shown on the drawings. Air handling unit shall be configured in a side-by-side dual duct arrangement with single side access.

C. Units shall fit into the space available with adequate clearance for service. Units may ship completely assembled or be shipped as disassembled modules and be re-assembled in the field by the Design Builder. Furnish sufficient gaskets and bolts for re-assembly. Provide certified ratings conforming to the latest edition of AMCA 211, 300, 301, 500 and ARI 410. Electrical components and assemblies shall comply with NEMA standards. 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.” Comply with NFPA 70, “National Electrical
Code,” as applicable for installation and electrical connections of ancillary electrical components of air handling units. Units shall be UL or ETL listed.

D. Unit Base / Floor: Provide a full perimeter welded base frame manufactured with structural Aluminum tubing and cross support members on close centers. Formed metal base rails with bolted or screwed support members are not acceptable. Fit base rails with lifting lugs at the corner of the unit or section (if de-mounted). The base shall consist of a 4-inch thick insulated “double bottom” floor with minimum 0.063 in. Aluminum outer and 0.250 in Aluminum treadplate inner walk-on surface. Caulk and seal all floor seams for an airtight unit. Single wall floors are not acceptable. Attach base frame to the unit at the factory with mechanical fasteners on center with no greater than 9”.

1. Base to have suitable size and number of lifting lugs / hold-down clips suitable for neoprene pad supports and field anchor bolting. See Section 23 05 29 – Hangers, Supports, and Seismic Restraints for HVAC Equipment and drawings for additional information.

   a. Unit base frame is to be of sufficient strength and stiffness to avoid noticeable deflection when the unit is elevated on neoprene pads at the lifting lugs / hold-down clips. See drawings for detail.

2. Dimensions shown on the drawings are nominal. Carefully coordinate position and size of supply air discharge, piping points of connection, access doors, etc. prior to fabrication.

3. Unit base shall be constructed for mounting isolation curb.

E. Exterior Panels

1. Outdoor units shall be specifically manufactured for weatherproof outdoor installation use. Indoor units engineered for indoor application and gasketed for outdoor use are not acceptable.

2. Fabricate the exterior panel from formed minimum 0.080 in. Aluminum with exterior coating as specified below. Units utilizing standing seam construction shall use 14 gauge exterior panels and 14 gauge interior bulkheads. Floor shall be minimum 0.250 in. Aluminum treadplate style in all accessible sections. The air handling unit casing is to be of the “no-through-metal” design. Incorporate insulating thermal breaks into the casing structure so that, when fully assembled, there exists no path of continuous unbroken metal to metal conduction from inner to outer surfaces. Provide necessary support to limit casing deflection to 1/200 of the narrowest panel dimension. If panels cannot meet this deflection, add additional internal reinforcing. Caulk and seal panel seams for an airtight unit. Leakage rates shall be less than 1% at design static pressure.

3. The factory finish coat shall be a polyester resin powder coated paint that is designed for long term corrosion resistance meeting or exceeding (ASTM B-117) Salt Spray Resistance at 95 degrees F. 1,000 hrs. and (ASTM D-2247) Humidity Resistance at 95 degrees F. 1,000 hrs. The color shall be as directed. Units painted after fabrication are not acceptable.
F. **Double Wall Construction:** Unit shall have double wall construction with 0.063 in. solid Aluminum liner in the unit sections. Inner liner at fan array sections shall be perforated.
   1. Provide mylar lining between the insulation and all interior perforated panels.
   2. **Insulation:** Insulate entire unit section with a full 2" thick non-compressed fiberglass insulation. The insulation shall have an effective thermal conductivity (C) of .24 (BTU in./sq. ft.) 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). Encapsulate all insulation edges within the panel. All perforated sections shall have Tuf-Skin insulation with black acrylic coating as manufactured by Johns Manville, 3M, or approved equal.

G. **Access Doors:** Equip unit with solid double wall insulated, hinged access doors as shown on the plans. Sizes shown on the drawings are nominal. Doors are to be adequately sized to pass equipment requiring potential replacement, such as motors. The doorframe shall be extruded aluminum with a built in thermal break barrier and full perimeter gasket. Doors shall be hinged using a minimum of two heavy-duty 10 gauge galvanized (or Stainless) steel butt hinges, and shall be provided with a 12 x 12 dual thermal pane windows with desiccant in the air space. There shall be two heavy duty Allegis or Ventlok 310 handles per door.

H. **Crane Rails:** There shall be a fixed crane rail above each motor, terminating at the access door, to allow the Owner to use a portable hoist to move the motor. Provide structural reinforcing to accommodate the weight of the rail, hoist, and transported motor.

I. **Vestibules**
   1. See drawings for vestibule arrangements for ventilated variable frequency drives (VFD), and accessories.
   2. Variable frequency drive vestibules shall be sized to accept factory-installed variable frequency drives separate from lighting and convenience outlet junction boxes and any Building Automation System panels. Access door(s) shall be arranged to provide code and manufacturer’s recommended access and clearance to the variable frequency drives. Vestibules shall be ventilated utilizing supply air from the supply fan discharge, located low in the vestibule enclosure and controlled with a volume damper, and with relief grille(s) near the top of the vestibule enclosure. When vestibule is not directly adjacent to the supply fan section, provide required ducting.

J. **Condensate Pan:** Provide double-sloped drain pans under cooling coils. Fabricate the drain pan from 16 gauge 304 stainless steel. All pans are to be sloped for complete drainage with no standing water in the unit. Insulate with 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. Actual size of drain connection is based on maximum possible total condensate load. Stacked coils are furnished with 16
gauge welded 304 stainless steel intermediate drain pans with copper downspouts to lowest drain pan.

K. Supply and Return Fan Arrays: Minimum Class III, SWSI airfoil Plenum type, direct drive as indicated on the drawings.

1. Number of fans in array arrangement as scheduled. Fan Array shall be sized and configure for N+1 with one fan and VFD as backup.

L. Plug Fan Array Assembly:

1. Fan performance shall be based on tests run in an AMCA certified laboratory as administered in accordance with AMCA Standard 210. Fan array shall be selected for N+1 duty. All fans shall be minimum class III and fan performance shall be available in manufacturer’s published catalogs. Fan shall be sized to perform as scheduled in the contract documents. The wheel diameter shall not be less than that scheduled in the Contract document and shall be constructed to AMCA Class Standards as applicable for the scheduled duty. Provide plenum fan wheel enclosures and belt guards.

2. The direct-drive fan and motor shall be mounted on a fully welded, rigid steel base. Unpainted or galvanized, bolted-together or non-welded steel bases are not acceptable. The structure supporting the bearing pedestal shall be fabricated from welded formed steel. Each fan shall be provided with coplanar silencer module with zero pressure drop backdraft damper. Fan shall be factory balanced and assembled for vibration free operation without the need for external spring vibration isolation.

3. Each fan/motor assembly shall be dynamically balanced to meet AMCA standard 204-96, for fan application class BV-5, to meet or exceed a rotational imbalance Grade .55, producing a maximum rotational imbalance of .022” per second peak, filter in (.55mm per second peak, filter in). “Filter in” measurement indicates that the specified balance grade must be achieved at the submitted design operating speed for the fan(s). Fan and motor assemblies submitted for approval incorporating larger than 215T frame shall be balanced in three orthogonal planes to demonstrate compliance with the G.55 requirement with a maximum rotational imbalance of .022” per second peak filter in (.55 mm per second peak, filter in).

4. The fan shall be direct-drive centrifugal airfoil blade, plug type and shall be designed to operate at cataloged performance without an involute housing. The wheels shall be fabricated from heavy gauge extruded aluminum air foil blades.

5. Fan bearings shall be ball or roller type. Sleeve bearings are not acceptable. Bearings shall have replaceable bearing inserts so the entire housing need not be replaced. The bearing shall be self-aligning to assist in the shaft alignment. Self-locking collars shall be provided to secure the bearing to the shaft. The bearing housing shall be cast-iron. Bearings shall be permanently sealed with grease. Bearings shall have a minimum L-10 life hour of 200,000 on all fans.
6. Motors shall be premium efficiency VFD rated with shaft grounding ring, full wash-down type, TEFC or TEAO, RPM as scheduled on drawings. See specification section 23 05 13 for minimum efficiency.

7. Fans shall be supplied with piezo ring flow measuring system with transmitter capable of supplying a 4 to 20 ma output signal to BMS that is proportional to airflow. The flow measuring system shall consist of a flow measuring station and a flow transmitter, both factory mounted and plumbed.

8. The flow measuring station shall consist of total and static pressure pick-ups at various positions of the fan inlet con of all fans in a fan array. The flow measuring station shall not obstruct the inlet to the fan and shall not have any effect on fan performance (flow or static pressure) or fan sound power levels. Air handler manufacturer shall provide PLC controller to read and totalize the airflow of the running fans for total airflow.

9. The electronic flow transmitter shall be mounted on the exterior of the fan section.

10. The transmitter shall not be damaged by over pressurization up to 200 times greater than span, and shall be furnished with a factory calibrated span and integral zeroing means. The transmitter shall be housed in a molded polyethylene enclosure with external signal tubing, power, and output connections.

11. Each fan in the array shall be equipped with zero pressure lost backdraft damper for automatic fan isolation. Fan selection and performance shall account for the backdraft damper requirement.

12. Fan system shall have no airflow turndown limitations and shall be able to maintain design static pressure at partial airflow. As controlled by manufacturer’s fan controller, system shall turn off fans individually to ensure stable performance at low airflow rates.

M. Variable Frequency Drives: Provide one variable frequency drive for each of the fan in the fan array including the standby fan. Drives shall be factory wired to each of the fan motors. Refer and conform to specification section 23 05 14 for variable frequency drive requirement.

1. Provide one Variable Frequency Drive per motor in the FAWALL to start, run and protect all motors in the fan array. The Variable Frequency Drives shall be sized based on the full load of the fan array. The Variable Frequency Drive shall include an onboard pressure transducer for monitoring airflow across the fans. Each VFD shall have an integrated disconnect capable of lock-out/tag-out requirements.

2. The Variable Frequency Drive shall be plenum rated and mounted in the airstream to each fan cube in the fan discharge section, and wired back to a dedicated enclosure for connection to the single point power. Dedicated electrical enclosure shall be provided single recessed touch screen keypad for up all the
unit’s Variable Frequency Drives for operation and programming. Main disconnecting means shall be provided in the dedicated electrical enclosure.

3. Provide three phase power distribution wiring and control wiring as required. All three phase power components shall have a rating listed for Short Circuit Current Rating. Provide control wiring and components required for complete operation of the fan array system.

4. VFDs shall have the ability to quick connect through Ethernet cables in a daisy chain configuration.

5. Each VFD shall be capable of auto-commissioning and transferring data to other drives in the system through a copy/paste function.

6. Each VFD shall be capable of operating in an environment with up to 95% Humidity-Condensing.

7. Each VFD shall come with Real-time Ripple Reduction, or R3 Filtering for harmonic reduction.

N. Motors and Drives: Per Section 23 05 12 – Common Motor and Drive Requirements for HVAC Equipment. Provide TEFC specified efficiency motor.

O. Coils:

1. Chilled and Heating Water Coils maximum face velocity limit to 450 feet per minute.

2. Coil performance shall be ARI certified and labeled, counter flow design finned coils with 5/8” O.D. seamless copper tubes, minimum 0.035” thick tube wall; 0.008 inch aluminum fins with maximum 10 fins per inch, unless specifically shown otherwise, tubes mechanically expanded into fins, 16 gauge 304 stainless steel casing, copper headers and connectors. Provide drain and vent connections to each section. Test at 315 PSI.

P. Filters:

1. Size, arrangement, capacity, efficiency and initial pressure drop as shown on the Drawings. Filters shall be front loaded.
   a. Efficiency per ASHRAE 52.1 and Minimum Efficiency Reporting Value (MERV) per ASHRAE 52.2.
   b. In addition to the installed final filter media and disposable pre-filter, provide one additional set of disposable pre-filters.

2. Pre-Filters: 4” MERV 8.
   a. For air handler upstream/downstream servicing: Camfil Farr, American Air filter, Flanders, or approved equal, galvanized steel construction. There shall be felt gaskets around the inside of the retainer and multiple
retaining clips, suitable for upstream or downstream installation and servicing.

b. Air handler fans’ total static pressure calculation shall include manufacturer’s recommend initial static pressure at the operating face velocity plus an additional 0.70” static pressure loss dirty filter allowance for the cold deck and an additional 0.90” static pressure loss dirty filter allowance for the hot deck.

3. Accessories

a. Air Filter Gauges: Dwyer Magnahelic 2001 or approved equal, with 4” diameter, 0-3” scale, static tips, mounting frame. Provide copper tube connections and specified gauge cocks on upstream and downstream side of each filter element. Clip minimum 1/8” copper tubing every 18”. Probes in air stream to be stainless steel. Provide one filter gauge for each filter bank. Provide sunshield for air filter gauge.

Q. Economizer Dampers

1. Dampers shall meet and exceed California Energy Code requirement for economizer damper leakage performance.

2. Outside Air Dampers:

a. Provide Ruskin EME3625, extruded aluminum wind driven rain resistant louver and CD-50 class 1A airfoil blade outside air control damper or equal.

b. On dedicated minimum outside air opening, provide Ruskin AML6, extruded aluminum wind driven rain resistant airflow sensing louver with integrated airflow measuring station and CD-50 class 1A airfoil blade outside air control damper or equal. Pressure transducer should be provided by BMS Design Builder.

3. Return and Exhaust Air Dampers

a. Ruskin CD-50, Air Balance, Inc., or approved equal. Units shall be entirely galvanized steel construction with 16 GA x 5” frame, opposed 16 GA x 6” airfoil blades, concealed damper linkage, vinyl damper seals bearings, and bearing seals. Pressure loss shall not exceed 0.12” w.g. when passing air at 2000 FPM velocity. Air leakage shall be less than 2 cfm/sf when shut-off against 1” w.g. pressure differential.

4. Each section of a damper bank shall be no larger than 60” x 40” maximum. All linkages shall be ganged together except as noted. Provide one damper motor for approximately each 16-square for section of damper and one for the minimum outside air section (if applicable), each operating on a separate shaft. The actuators shall be sized at the maximum torque allowable by the dampers. Provide supporting documentation.
a. Arrange dampers to accept damper actuators of the type to be installed by Section 23 09 00 – Instrumentation and Controls for HVAC.

R. Louvers

1. Louvers shall be designed to collect and drain rainwater to outside of unit. Outside air louvers shall be wind-driven rain resistant and shall be sized for a maximum face velocity of 700 fpm based on gross louver area. Louvers shall have zero water penetration at 800 ft/min air velocity.

S. Electrical

1. Furnish each section with one 120 volt single phase vapor-proof marine-type LED light fixture with guard wired to a single combination pilot light switch with timer. Provide duplex GFCI receptacle mounted in a NEMA 3R enclosure adjacent to the access door on the exterior of the unit casing near each of the fan array. All lights, switches, and duplex receptacles shall be pre-wired at the factory into one junction box for connection to the building electrical system. Provide separate circuits for lights and receptacles. Each circuit is to be 20 amperes. Locate circuit junction box in a vestibule.

2. Provide a junction box with another dedicated circuit in the VFD vestibule for a BAS control panel.

3. Provide power to any provided accessories such as air flow measurement pressure transmitter, etc.

4. Provide factory electrical wiring for all of the fan motors and VFD’s within the fan array with an electrical disconnect ready for field electrical power connections. Each fan array shall be separately powered from the electrical system, one for the supply fan array and one for the return fan array.

5. Electrical disconnects conduits, wiring, junction boxes, lighting, etc. to conform to Division 26 Electrical and NEC requirement.


2.03 ROOF CURB

A. Provide seismic isolation curb to continuously support the unit on the roof. Vibration isolators shall have 2 inch static deflection.

B. Manufacturer shall be Mason MW, Sausse, Kinetics, or equal.

PART 3 - EXECUTION

3.01 AIR HANDLERS

A. General
1. Coordinate ventilated vestibule space requirements and conduit/wiring requirements with Section 232923 - Variable Frequency Drives.

2. Coordinate pad requirements.

3. Set in place using manufacturer's recommended rigging attachments. Attach air handler to pad as detailed on the drawings.

4. Install and join air handler sections in the field. All joints shall be sealed airtight.
   a. Adjust doors, dampers, etc.
   b. Connect all internal wiring between sections.

5. Repair nicks in finish.

6. Provide training on the operation and maintenance of the air handlers and components.

B. Coils

1. Comb fins and thoroughly clean.

2. Run condensate drains with p-traps and vents to receptacles.

C. Dampers

1. Coordinate actuator mounting requirements with the Environmental Control System Design Builder.

D. Filters and Accessories

1. During construction and start-up, do not run fans without filters in place. Include construction media filters over pre-filters and final filters. Leave construction media in place until the systems are under final testing.

2. After substantial completion and prior to occupancy, perform the required 100% outside air flush-out. Install the second set of filters for the flush-out if the first set of filters is too dirty for use during the flush-out period.

3. After completion of the flush-out and prior to occupancy, replace the pre-filters and final filters with a new set of filters. Turn over any remaining filters to the District.

4. Air filter gauges: Install a gauge at the pre-filter bank and at the final filter bank with static tips upstream and downstream of each filter bank. Mount gauges on duct wall adjacent to filter bank, as close to eye level as possible. Seal duct penetrations airtight.

E. Field insulate internal piping, valves, and accessories.
F. Mount unit on seismic isolation curb per the manufacturer's direction.

END OF SECTION
PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Indoor and Outdoor Air Handling Units

1.02 RELATED DOCUMENTS

A. Section 23 05 00 – Common Results for HVAC

B. Section 23 05 12 – General Motor Requirements for HVAC and Steam Generation Equipment

C. Section 23 05 48 – Vibration and Seismic Controls for HVAC System and Equipment

D. Section 23 05 93 – Testing Adjusting and Balancing for HVAC

E. Section 23 29 23 – Variable Frequency Drives

F. Section 23 34 16 – Centrifugal HVAC Fans

G. Section 23 40 00 – HVAC Air Cleaning Devices

1.03 SUBMITTALS

A. Submit in accordance with Agreement for Mechanical and Control Design-Build Project and Section 230500

B. Product Data:

1. Air Handlers: Construction, features, dimensions, weight, sound power level, vibration isolation, seismic restraint, certified performance.

1.04 REPORTS

A. Furnish fan performance curves depicting the operating point described on schedule for each individual fan.

B. Furnish fan vibration nomograph generated during fan balance test for each individual fan. This data shall be furnished upon completion of fabrication of units.

C. Furnish sound power levels at supply connection, return connection, and casing radiation for each air handling unit. Test data shall show sound power levels, re: 10-12 watts for each of the eight octave band center frequencies.
1.05 OPERATION AND MAINTENANCE DATA

A. Startup and service procedures.

B. Lubrication schedule.

PART 2 - PRODUCTS

2.01 OUTDOOR ROOFTOP AIR HANDLING UNIT

A. Manufacturers: The following manufacturers are approved for use. No substitutions will be permitted.

1. Carrier Daikin Applied ‘Skyline’, Trane or equal.

B. General Description

1. Configuration: Fabricate as detailed on prints.

2. Performance: Conform to AHRI 410 and 430 Standards. See schedules on prints.

3. Acoustics: Sound power levels (dB) for the unit shall not exceed the specified levels shown on the unit schedule. The manufacturer shall provide the necessary sound treatment to meet these levels if required.

C. Unit Construction

1. Fabricate unit with heavy gauge channel posts and panels secured with mechanical fasteners. All panels, access doors, and ship sections shall be sealed with permanently applied bulb-type gasket. Shipped loose gasketing is not allowed.

2. Panels and access doors shall be constructed as a 2-inch nominal thick; thermal broke double wall assembly, injected with foam insulation with an R-value of not less than R-13.

   a. The outer panel shall be constructed of G60 painted galvanized steel.

   b. The inner liner shall be constructed of G90 galvanized steel.

   c. The floor plate shall be constructed as specified for the inner liner.

   d. Unit will be furnished with solid inner liners.

3. Panel deflection shall not exceed L/240 ratio at 125% of design static pressure, maximum 5 inches of positive or 6 inches of negative static pressure. Deflection shall be measured at the panel midpoint.
4. The casing leakage rate shall not exceed 0.50 cfm per square foot of casing surface area at design static pressure up to a maximum of +5" w.c. in positive pressure sections and -6" w.c. in negative pressure sections (.0025 m³/s per square meter of cabinet area at 1.24 kPa static pressure).

5. Module to module field assembly shall be accomplished with an overlapping, full perimeter internal splice joint that is sealed with bulb type gasketing on both mating modules to minimize on-site labor and meet indoor air quality standards.

6. Access doors shall be flush mounted to cabinetry, with minimum of two six inch long stainless steel piano-type hinges, latch and full size handle assembly. Access doors shall swing outward for unit sections under negative pressure. Access doors on positive pressure sections, shall have a secondary latch to relieve pressure and prevent injury upon access.

7. Provide cross broke roofcap system to divert water from the top surface of the air handler. The rain shed roofcap shall have 2" standing seams covered with splice cap channels to seal top seam. Splice cap shall break down over sides of standing seam to protect the ends of the seam.

8. The unit shall have a 6-inch curb ready base for structural rigidity and condensate trapping. The curb-ready base shall be designed with sloped drip pans located under all unit sections except duct openings and shall be supported by frame member.

9. Roof curb shall be furnished by others. It shall be designed to allow for proper structural support and condensate trapping.

D. Fan Assemblies

1. Acceptable fan assembly shall be a single width, single inlet, class II, belt-drive type plenum fan dynamically balanced as an assembly, as shown in schedule. Maximum fan RPM shall be below first critical fan speed. Fan assemblies shall be dynamically balanced by the manufacturer on all three planes and at all bearing supports. Copper lubrication lines shall be provided and extend from the bearings and attached with grease fittings to the fan base assembly near access door. If not supplied at the factory, Design Builder shall mount copper lube lines in the field. Fan and motor shall be mounted internally on a steel base. Provide access to motor, drive, and bearings through hinged access door.

2. Fan and motor shall be mounted internally on a steel base. Factory mount motor on slide base that can be slid out the side of the unit if removal is required. Provide access to motor, drive, and bearings through hinged access door. Fan and motor assembly shall be mounted on 2" deflection spring vibration type isolators inside cabinetry.

E. Bearings, Shafts, And Drives

1. Bearings: Basic load rating computed in accordance with AFBMA - ANSI Standards. The bearings shall be designed for service with an L-50 life of
200,000 hours and shall be a heavy duty pillow block, self-aligning, grease-lubricated ball or spherical roller bearing type.

2. Shafts shall be solid, hot rolled steel, ground and polished, keyed to shaft, and protectively coated with lubricating oil. Hollow shafts are not acceptable.

3. V-Belt drives shall be cast iron or steel sheaves, dynamically balanced, bored to fit shafts and keyed. Fixed sheaves, matched belts, and drive rated based on motor horsepower. Minimum of 2 belts shall be provided on all fans with 10 HP motors and above. Standard drive service factor minimum shall be 1.1 S.F. for 1/4 HP – 7.5 HP, 1.3 S.F. for 10 HP and larger, calculated based on fan brake horsepower.

F. Electrical

1. The air handler(s) shall be ETL and ETL-Canada listed by Intertek Testing Services, Inc. Units shall conform to bi-national standard ANSI/UL Standard 1995/CSA Standard C22.2 No. 236.

2. Fan motors shall be manufacturer provided and installed, Totally Enclosed, premium efficiency (meets or exceeds EPAct requirements), 1750 RPM, single speed, 460V / 60HZ / 3P. Complete electrical characteristics for each fan motor shall be as shown in schedule.

3. Wiring Termination: Provide terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated. Enclosed terminal lugs in terminal box sized to NFPA 70.

4. Manufacturer shall provide ASHRAE 90.1 Energy Efficiency equation details for individual equipment to assist Building Engineer for calculating system compliance.

5. Installing Design Builder shall provide GFI receptacle within 25 feet of unit to satisfy National Electrical Code requirements.

6. Air handler manufacturer shall provide, mount and wire ABB variable speed drive with electrical characteristics such as indicated on project schedule and shown on manufacturer’s data sheets.

G. Filters

1. Furnish combination filter section with 2-inch pleated MERV 8 flat pre-filter and 12-inch Varicel SH cartridge 65% efficient (MERV 11) final filter. Provide side loading and removal of filters.

2. Filter media shall be UL 900 listed, Class I or Class II.

3. Filter Magnehelic gauge(s) shall be furnished and mounted by others.

H. Additional Sections
1. Plenum section shall be provided and properly sized for inlet and/or discharge air flow (between 600 and 1500 feet per minute). The plenum shall provide single or multiple openings as shown on drawings and project schedule.

2. Access section shall be provided for access between components. Floor options shall include .125-inch aluminum treadplate or drainpan as shown on project schedule.

3. Mixing box section shall be provided with end outside air opening and bottom return air opening with or without parallel low leak airfoil damper blades. Dampers shall be hollow core galvanized steel airfoil blades, fully gasketed and have continuous vinyl seals between damper blades in a galvanized steel frame. Dampers shall have stainless steel jamb seals along end of dampers. Connecting linkage and ABS plastic end caps shall be provided when return and outside air dampers are each sized for full airflow. Return and outside air dampers of different sizes must be driven separately. Damper Leakage: Leakage rate shall be less than two tenths of one percent leakage at 2 inches static pressure differential. Leakage rate tested in accordance with AMCA Standard 500.

2.02 INDOOR AIR HANDLING UNITS

A. General

1. Indoor mounted, draw-thru, VFD driven packaged air-handling unit that can be used in a vertical configuration. Unit shall consist of forward-curved belt-driven centrifugal fan(s), motor and drive assembly, pre-wired fan motor contactor, heating cooling coil, 2-in. disposable air filters, and condensate drain pans for vertical or horizontal configurations.

B. Base Unit:

1. Cabinet shall be constructed of mill-galvanized steel.

2. Cabinet panels shall be fully insulated with 1/2-in. (12.7-mm) fire-retardant material. Insulation shall contain an EPA-registered immobilized antimicrobial agent to effectively resist the growth of bacteria and fungi as proven by tests in accordance with ASTM standards G21 and 22 (U.S.A.).

3. Unit shall contain non-corroding condensate drain pans for both vertical and horizontal applications. Drain pans shall have connections on right and left sides of unit to facilitate field connection. Drain pans shall have the ability to be sloped toward the right or left side of the unit to prevent standing water from accumulating in pans.

4. Unit shall have factory-supplied 2-in. (51 mm) throwaway-type filters installed upstream from the cooling coil. Filter access shall be from either the right or left side of the unit.

C. Coils:
1. Chilled water coils shall be rated for an operating pressure of not less than 300 psig (2069 kPag).

2. Hot Water coils shall be 2-row, U-bend coil with copper tubes and aluminum plate fins bonded to the tubes by mechanical expansion. Coil shall be mounted in a galvanized steel housing that shall be fastened to the unit’s fan deck for blow-thru heating operation. Coil shall have maximum working pressure of 150 psig.

D. Motor:

1. Fan motor of the size and electrical characteristics specified on the equipment schedule shall be factory supplied and installed.

2. Motors rated at 1.3 through 3.7 hp shall have inherent thermal overload protection. Motors rated at 5 hp shall be protected by a circuit breaker.

3. Evaporator-fan motor shall have permanently lubricated, sealed bearings and inherent automatic-reset thermal overload protection or manual reset calibrated circuit breakers. Evaporator motors are designed specifically for Carrier and do not have conventional horsepower (hp) ratings listed on the motor nameplate. Motors are designed and qualified in the “air-over” location downstream of the cooling coil and carry a maximum continuous bhp rating that is the maximum application bhp rating for the motor; no “safety factors” above that rating may be applied.

4. All evaporator-fan motors 5 hp and larger shall meet the minimum efficiency requirements as established by the Energy Policy Act of 1992 (EPACT), effective October 24, 1997.

E. Special Features:

1. External Paint: Where conditions require, units shall be painted with an American Sterling Gray finish.

2. Variable Frequency Drive (VFD):
   a. Shall be installed inside the unit cabinet, mounted, wired and tested.
   b. Shall contain Electromagnetic Interference (EMI) frequency protection.
   c. Insulated Gate Bi-Polar Transistors (IGBT) used to produce the output pulse width modulated (PWM) waveform, allowing for quiet motor operation.
   d. Self-diagnostics with fault and power code LED indicator. Field accessory Display Kit available for further diagnostics and special setup applications.
   e. RS485 capability standard.
   f. Electronic thermal overload protection.
g. 5% swinging chokes for harmonic reduction and improved power factor.

h. All printed circuit boards shall be conformal coated.

PART 3 - EXECUTION

3.01 AIR HANDLERS

A. Set in place using manufacturer’s recommended rigging attachments. Mount outdoor unit with seismic isolation curb with 2 inch static deflection.

B. Where indicated, install flexible duct connections at inlet and outlet of each fan.

C. Adjust isolators and thrust restraints under actual operating condition so that the fan bases are free floating. All isolators shall have 2 inch static deflection.

D. Repair nicks in finish.

E. Connect power wiring from the lighting circuits to the power junction box. See electrical drawings. Installation shall be in accordance with Division 26 requirements.

F. Connect power-wiring from VFD’s to motors per Division 26 requirements.

END OF SECTION
PART 1 - GENERAL

1.01 SCOPE

A. The requirements of the General Conditions, Supplementary Conditions, Agreement for Mechanical and Control Design-Build Project and drawings apply to all work herein.

B. Provide microprocessor controlled, multiple compressor, air-cooled outdoor packaged rooftop air conditioning units, and components of the scheduled capacities and performance as shown and indicated on the drawings, including but not limited to: factory-packaged rooftop air conditioner, charge of refrigerant and oil, roof curb (where applicable), power and control connections, and utility connections.

1.02 RELATED DOCUMENTS

A. Division 22

B. Section 23 05 00 – Common Results for HVAC

C. Section 23 05 48 – Vibration and Seismic Controls for HVAC System and Equipment

D. Section 23 21 13 – Hydronic Piping

E. Section 23 31 13 – Metal Ducts

1.03 QUALITY ASSURANCE

A. Products will be designed, tested, and rated in accordance with, and installed in compliance with applicable sections of the most recent version of the following Standards and Codes:


2. Conform to UL for construction of rooftop packaged unit.

3. Manufactured in facility registered to ISO 9001

4. AMCA 210 – Laboratory Methods of Testing Fans for Rating Purposes

5. AMCA 300 – Test Code for Sound Rating Air Moving Devices

6. AMCA 301 – Method of Publishing Sound Ratings for Air Moving Devices

7. AMCA 500 – Test Methods for Louver, Dampers, and Shutters
8. ANSI/AFBMA 9 – Load Ratings and Fatigue Life for Ball Bearings
9. ANSI/UL 900 – Test Performance of Air Filter Units
10. ARI 410 – Forced-Circulation Air Cooling and Air Heating Coils
11. NFPA 90A – Installation of Air Conditioning and Ventilation Systems
12. SMACNA – Low Pressure Duct Construction Standards
14. AHRI 370 Sound Rating of Large Outdoor Refrigerating and Air Conditioning Equipment.

B. Factory Test: Unit will be wired, piped, and fully charged with refrigerant and oil at the factory. The unit will then undergo an automated operational run test and quality inspection prior to shipment.

C. Warranty: Manufacturer will warrant all equipment and material of its manufacture against defects in workmanship and material. Warranty coverage shall be as follows.

1. Entire unit – One (1) year parts and labor
2. Compressor – 2nd through 5th year, parts only
3. Warranty will not include parts or labor associated with routine maintenance, such as belts, air filters, etc.

1.04 DELIVERY AND HANDLING

A. Unit will be delivered to the job site fully assembled, wired, and charged with refrigerant and oil by Johnson Controls Inc. (JCI).

B. Unit will be stored and handled per manufacturer instructions.

C. All handling and storage procedures will be per manufacturer’s recommendations.
1.05 SUBMITTALS

A. Shop drawing submittals will include, but not limited to, the following: drawings indicating components, dimensions, weights, required clearances, and location, type and size of field connections, and power and control wiring connections.

B. Product data will include dimensions, weights, capacities, ratings, fan performance, motor electrical characteristics, and gauges and finishes of materials. The following additional information will be provided.

1. Product data for filter media
2. Electrical requirements for power supply wiring
3. Manufacturer’s standard published installation instructions

C. Manufacturer’s standard operating and maintenance instructions will be supplied.

PART 2 - PRODUCTS

2.01 MANUFACTURER

A. Carrier
B. Trane
C. Or equal

2.02 PACKAGE ROOFTOP GAS/ELECTRIC AC UNIT (2 TO 5 TONS)

A. General: Factory--assembled, single--piece, heating and cooling unit. Contained within the enclosure shall be all factory wiring, piping, controls, refrigerant charge with R--410A refrigerant, and special features required prior to field start--up.

B. Unit Cabinet:

1. Unit cabinet shall be constructed of phosphated, zinc-coated, pre-painted steel capable of with-standing 500 hours in salt spray.

2. Normal service shall be through 3 removable cabinet panels.

3. The unit shall be constructed on a rust proof unit base that has an externally trapped, integrated sloped drain.

4. Evaporator fan compartment top surface shall be insulated with minimum 1/2-in. (12.7 mm) thick, flexible fiberglass insulation, coated on the air side and retained by adhesive and mechanical means. The evaporator wall sections will be insulated with a minimum semi-rigid foil- faced board capable of being wiped clean. Aluminum foil- faced fiberglass insulation shall be used in the entire indoor air cavity section.
5. Unit shall have a field-supplied condensate trap.

C. Fans:
   1. The evaporator fan shall be a multi-speed, direct-drive, as shown on equipment drawings.
   2. Fan wheel shall be made from steel, be double--inlet type with forward curved blades with corrosion resistant finish. Fan wheel shall be dynamically balanced.
   3. Condenser fan shall be direct drive propeller type with aluminum blades riveted to corrosion resistant steel spiders, be dynamically balanced, and discharge air vertically.

D. Compressor:
   1. Fully hermetic compressors with factory-installed vibration isolation.
   2. Two-stage scroll compressors shall be standard on all units.

E. Coils:
   1. Evaporator and condenser coils shall have aluminum plate fins mechanically bonded to seamless copper tubes with all joints brazed. Tube sheet openings shall be belled to prevent tube wear.

F. Heating Section:
   1. Induced-draft combustion type with energy saving direct spark ignition system and redundant main gas valve.
   2. Induced-draft motors shall provide adequate airflow for combustion.
   3. The heat exchangers shall be constructed of aluminized steel for corrosion resistance.
   4. Burners shall be of the in-shot type constructed of aluminum coated steel.
   5. All gas piping and electric power shall enter the unit cabinet at a single location.

G. Refrigerant Components:
   1. Refrigerant expansion device shall be of the TSXV (thermostatic expansion valve) type.

H. Filters:
   1. Filter section shall consist of field-installed, throwaway, 1in (25 mm) thick fiberglass filters of commercially available sizes.
I. Controls and Safeties:
   1. Unit controls shall be complete with a self-contained low voltage control circuit.
   2. Compressors shall incorporate a solid-state compressor protector that provides reset capability.

J. Operating Characteristics:
   1. Unit shall be capable of starting and running at 125_F (51_C) ambient outdoor temperature per maximum load criteria of AHRI Standard 210.
   2. Compressor with standard controls shall be capable of operation down to 40_F (4_C) ambient outdoor temperature.
   3. Units shall be provided with fan time delay to prevent cold air delivery before the heat exchanger warms up.
   4. Unit shall be provided with fan time delay after the thermostat is satisfied.

K. Electrical Requirements:
   1. All unit power wiring shall enter the unit cabinet at a single location.

L. Motors:
   1. Compressor motors shall be of the refrigerant-cooled type with line-break thermal and current overload protection.
   2. All fan motors shall have permanently lubricated bearings, and inherent, automatic reset, thermal overload protection.
   3. Condenser fan motor shall be totally enclosed.
   4. Evaporator Fan Motor to be multi-speed ECM blower motor.

M. Compressor Protection:
   1. Solid-state control shall protect compressor by preventing “short-cycling”.

N. Low NOx:
   1. Shall provide NOx reduction to values below 40 nanograms/ joule to meet California’s and other localities’ emission requirements as shipped from factory.

O. Special Option/Kits Available:
   1. Provide one-stage heating and cooling in addition manual or automatic changeover and indoor fan control.
2. Provide BACnet interface for communication with the Building BAS.


4. Economizer for two-stage operation: (Horizontal and Vertical with Jade Honeywell W7220 controller, Honeywell communicating actuator, and dry bulb sensor. (Contact MicroMetl Customer Service at 1--800--662--4822 to order.).
   a. Economizer controls capable of providing free cooling using outside air.
   b. Equipped with low leakage dampers not to exceed 3% leakage, at 1.0 IN. W.C. pressure differential.
   c. Spring return motor shuts off outdoor damper on power failure.

5. Filter Rack Option or Kit: Shall provide filter mounting for downflow applications. Offered as an accessory or as a factory installed option.

6. Flat Roof Curb Kit: Curbs shall have seal strip and a wood nailer for flashing and shall be installed per manufacturer’s instructions.

7. Flue Discharge Deflector Kit: Directs flue gas exhaust; 90 degrees upward from current discharge.


2.03 ROOFTOP PACKAGED HEAT PUMP (3 TO 10 TON)

A. Self-Contained Heat Pump

1. General:
   a. Outdoor, rooftop mounted, electrically controlled, heating and cooling unit utilizing hermetic scroll compressor(s) for cooling duty and heat pump for heating duty.
   b. Factory assembled, single piece heating and cooling rooftop unit. Contained within the unit enclosure shall be all factory wiring, piping, controls, and special features required prior to field start-up.
   c. Unit shall use R410A refrigerant.
   d. Unit shall be installed in accordance with the manufacturer’s instructions.
   e. Unit must be selected and installed in compliance with local, state, and federal codes.

2. Operating Characteristics
a. Unit shall be capable of starting and running at 125°F (52°C) ambient outdoor temperature, meeting maximum load criteria of AHRI Standard 210/240 or 340/360 at ±10% voltage.

b. Compressor with standard controls shall be capable of operation down to 30°F (-1°C), ambient outdoor temperatures. Accessory Low Ambient controls are available if mechanically cooling at ambient temperatures below 30°F (-1°C).

c. Unit shall be capable of simultaneous heating duty and defrost cycle operation when using accessory electric heaters.

d. Unit shall discharge supply air vertically or horizontally as shown on contract drawings.

e. Unit shall be factory configured for vertical supply and return configurations.

f. Unit shall be field convertible from vertical to horizontal configuration. No special kits on 04-09 sizes. Size 12 model shall require a supply duct kit for field installation.

g. Unit shall be capable of mixed operation: vertical supply with horizontal return or horizontal supply with vertical return.

B. Electric and Electronic Control System

1. General:
   a. Shall be complete with self-contained low voltage control circuit protected by a resettable circuit breaker on the 24-v transformer side. Transformer shall have 75VA capability.

   b. Shall utilize color-coded wiring.

   c. Shall include a central control terminal board to conveniently and safely provide connection points for vital control functions such as: smoke detectors, phase monitor, economizer, thermostat, DDC control options, loss of charge, freeze switch, high pressure switches.

   d. Unit shall include a minimum of one 8-pin screw terminal connection board for connection of control wiring.

   e. Shall include integrated defrost system to prevent excessive frost accumulation during heating duty, and shall be controlled as follows:

      1) Defrost shall be initiated on the basis of time and coil temperature.
2) A 30, 60, 90, 120 minute timer shall activate the defrost cycle only if the coil temperature is low enough to indicate a heavy frost condition.

3) Defrost cycle shall terminate when defrost thermostat is satisfied and shall have a positive termination time of 10 minutes.

f. Defrost system shall also include:

1) Defrost Cycle Indicator LED.

2) Dip switch selectable defrost time between 30, 60, 90 and 120 minutes. Factory set at 30 minutes.

3) Molded plug connection to insure proper connection.

2. Safeties:

a. Compressor over-temperature, overcurrent.

b. Loss of charge switch.

1) Units with 2 compressors shall have different sized connectors for the circuit 1 and circuit 2 loss of charge switches. They shall physically prevent the cross-wiring of the safety switches between circuits 1 and 2.

2) Loss of charge switch shall use different color wire than the high-pressure switch. The purpose is to assist the installer and service technician to correctly wire and or troubleshoot the rooftop unit.

c. High-pressure switch.

1) Units with 2 compressors shall have different sized connectors for the circuit 1 and circuit 2 high pressure switches. They shall physically prevent the cross-wiring of the safety switches between circuits 1 and 2.

2) High-pressure switch shall use different color wire than the low-pressure switch. The purpose is to assist the installer and service technician to correctly wire and or troubleshoot the rooftop unit.

d. Freeze protection thermostat, evaporator coil.

e. Automatic reset, motor thermal overload protector.

3. Unit Cabinet
a. Unit cabinet shall be constructed of galvanized steel, and shall be bonderized and coated with a pre-painted baked enamel finish on all externally exposed surfaces.

b. Unit cabinet exterior paint shall be: film thickness, (dry) 0.003 inches minimum, gloss (per ASTM D523, 60°F): 60, Hardness: H-2H Pencil hardness.

c. Evaporator fan compartment interior cabinet insulation shall conform to AHRI Standards 210/240 or 340/360 minimum exterior sweat criteria. Interior surfaces shall be insulated with a minimum 1/2- in. thick, 1 lb density, flexible fiberglass insulation, neoprene coated on the air side. Aluminum foil-faced fiberglass insulation shall be used in the heat compartment.

d. Unit internal insulation linings shall be resistant to mold growth in accordance with “mold growth and humidity” test in ASTM C1338, G21, and UL 181 or comparable test method. Air stream surfaces shall be evaluated in accordance with the “Erosion Test” in UL 181, as part of ASTM C1071.

e. Base of unit shall have a minimum of three locations for thru-the-base electrical connections (factory-installed or field-installed), standard.

f. Base Rail

1) Unit shall have base rails on a minimum of 2 sides.

2) Holes shall be provided in the base rails for rigging shackles to facilitate maneuvering and overhead rigging.

3) Holes shall be provided in the base rail for moving the rooftop by fork truck.

4) Base rail shall be a minimum of 16 gauge thickness.

g. Condensate pan and connections:

1) Shall be a sloped condensate drain pan made of a non-corrosive material.

2) Shall comply with ASHRAE Standard 62.

3) Shall use a 3/4- in. - 14 NPT drain connection, possible either through the bottom or end of the drain pan. Connection shall be made per manufacturer’s recommendations.

h. Electrical connections:

1) All unit power wiring shall enter unit cabinet at a single, factory prepared, knockout location.
2) Thru-the-base capability.
   a) Standard unit shall have a thru-the-base electrical location(s) using a raised, embossed portion of the unit basepan.
   b) Optional, factory approved, watertight connection method must be used for thru-the-base electrical connections.
   c) No basepan penetration, other than those authorized by the manufacturer, is permitted.

i. Component access panels (standard)
   1) Cabinet panels shall be easily removable for servicing.
   2) Unit shall have one factory-installed, tool-less, removable, filter access panel.
   3) Panels covering control box, indoor fan, indoor fan motor, and compressors shall have molded composite handles.
   4) Handles shall be UV modified, composite, permanently attached, and recessed into the panel.
   5) Screws on the vertical portion of all removable access panels shall engage into heat resistant, molded composite collars.
   6) Collars shall be removable and easily replaceable using manufacturer recommended parts.

4. Coils
   a. Standard Aluminum/Copper Coils: on all models.
      1) Standard evaporator and condenser coils shall have aluminum lanced plate fins mechanically bonded to seamless internally grooved copper tubes with all joints brazed.
      2) Evaporator coils shall be leak tested to 150 psig. Pressure tested to 450 psig and qualified to UL 1995 burst test at 1775 psig.
      3) Condenser coils shall be leak tested to 150 psig. Pressure tested to 650 psig and qualified to UL 1995 burst test at 1980 psig.
   b. Optional Pre-coated aluminum fin condenser coils: on all models.
      1) Shall have a durable epoxy-phenolic coating to provide protection in mildly corrosive coastal environments.
2) Coating shall be applied to the aluminum fin stock prior to the fin stamping process to create an inert barrier between the aluminum fin and copper tube.

3) Epoxy-phenolic barrier shall minimize galvanic action between dissimilar metals.

4) Corrosion durability of fin stock shall be confirmed through testing to be no less than 6000 hours salt spray per ASTM B117-90.

5) Corrosion durability of fin stock shall be confirmed through testing to have no visible corrosion after 48 hour immersion in a room temperature solution of 5% salt, 1% acetic acid.

6) Fin stock coating shall pass 2000 hours of the following: one week exposure in the prohesion chamber followed by one week of accelerated ultraviolet light testing. Prohesion chamber: the solution shall contain 3.5% sodium chloride and 0.35% ammonium sulfate. The exposure cycle is one hour of salt fog application at ambient followed by one hour drying at 95°F (35°C).

5. Refrigerant Components

a. Refrigerant circuit shall include the following control, safety, and maintenance features:

1) Thermostatic Expansion Valve (TXV) shall help provide optimum performance across the entire operating range. Shall contain removable power element to allow change out of power element and bulb without removing the valve body.

2) Refrigerant filter drier on each refrigerant circuit.

3) Service gauge connections on suction and discharge lines.

4) Pressure gauge access through a specially designed access port in the top panel of the unit.

5) Suction line accumulator to provide protection in all operating modes from cooling, heating and reverse cycle switching. Standard on each refrigerant circuit.

b. There shall be gauge line access port in the top of the rooftop, covered by a black, removable plug.

1) The plug shall be easy to remove and replace.

2) When the plug is removed, the gauge access port shall enable maintenance personnel to route their pressure gauge lines.
3) This gauge access port shall facilitate correct and accurate condenser pressure readings by enabling the reading with the compressor access panel on.

4) The plug shall be made of a leak proof, UV-resistant, composite material.

c. Compressors

1) Unit shall use one fully hermetic, scroll compressor for each independent refrigeration circuit.

2) Models shall be available with single compressor/single stage cooling designs on 04-07 models, single compressor/2-stage cooling on 07 size, and 2 compressor/2-stage cooling models on 08-12 sizes.

3) Compressor motors shall be cooled by refrigerant gas passing through motor windings.

4) Compressors shall be internally protected from high discharge temperature conditions.

5) Compressors shall be protected from an overtemperature and over-amperage conditions by an internal, motor overload device.

6) Compressor shall be factory mounted on rubber grommets.

7) Compressor motors shall have internal line break thermal, current overload and high pressure differential protection.

8) Crankcase heaters shall be utilized on all models to protect compressor with specific refrigerant charge.

6. Filter Section

a. Filters access is specified in the unit cabinet section of this specification.

b. Filters shall be held in place by a pivoting filter tray, facilitating easy removal and installation.

c. Shall consist of factory-installed, low velocity, throw-away 2-in. thick fiberglass filters.

d. Filters shall be standard, commercially available sizes.

e. Only one size filter per unit is allowed.

7. Evaporator Fan and Motor

a. Evaporator fan motor:
1) Shall have permanently lubricated bearings.

2) Shall have inherent automatic-reset thermal overload protection or circuit breaker.

3) Shall have a maximum continuous bhp rating for continuous duty operation; no safety factors above that rating shall be required.

b. Belt-driven Evaporator Fan:

1) Belt drive shall include an adjustable pitch motor pulley.

2) Shall use sealed, permanently lubricated ball-bearing type.

3) Blower fan shall be double inlet type with forward curved blades.

4) Shall be constructed from steel with a corrosion resistant finish and dynamically balanced.

5) Standard on all 07-12 size models. Optional on all 04-06 3-phase models.

8. Condenser Fans and Motors

a. Condenser fan motors:

1) Shall be a totally enclosed motor.

2) Shall use permanently lubricated bearings.

3) Shall have inherent thermal overload protection with an automatic reset feature.

4) Shall use a shaft down design on all sizes.

b. Condenser Fans:

1) Shall be a direct driven propeller type fan.

2) Shall have aluminum blades riveted to corrosion resistant steel spiders and shall be dynamically balanced.

9. Controls

a. Thermostats

1) have capability to energize 2 different stages of cooling, and 2 different stages of heating

2) include capability for occupancy scheduling
b. Direct-digital control system for HVAC

1) Shall be ASHRAE 62 compliant.

2) Shall accept 18-30VAC, 50-60Hz, and consumer 15VA or less power.

3) Shall have an operating temperature range from -40°F (-40°C) to 130°F (54°C), 10% - 90% RH (non-condensing).

4) Shall include built-in protocol for BACnet (MS/TP and PTP modes), Modbus** (RTU and ASCII), Johnson N2 and LonWorks. LonWorks Echelon processor required for all Lon applications shall be contained in separate communication board.

5) Shall allow access of up to 62 network variables (SNVT). Shall be compatible with all open controllers

6) Baud rate Controller shall be selectable using a dipswitch.

7) Shall have an LED display independently showing the status of serial communication, running, errors, power, all digital outputs, and all analog inputs.

8) Shall accept the following inputs: space temperature, setpoint adjustment, outdoor air temperature, indoor air quality, outdoor air quality, compressor lock-out, fire shutdown, enthalpy switch, and fan status/filter status/humidity/remote occupancy.

9) Shall provide the following outputs: economizer, fan, cooling stage 1, cooling stage 2, heat stage 1, heat stage 2, heat stage 3/exhaust/reversing valve.

10) Shall have built-in surge protection circuitry through solid state polyswitches. Polyswitches shall be used on incoming power and network connections. Polyswitches will return to normal when the “trip” condition clears.

11) Shall have a battery back-up capable of a minimum of 10,000 hours of data and time clock retention during power outages.

12) Shall include an EIA-485 protocol communication port, an access port for connection of either a computer or a Carrier technician tool, an EIA-485 port for network communication to intelligent space sensors and displays, and a port to connect an optional LonWorks communications card.

13) Software upgrades will be accomplished by either local or remote download. No software upgrades through chip replacements are allowed.
10. Special Features, Options and Accessories

a. Integrated Economizer.

1) Integrated, gear driven opposing modulating blade design type capable of simultaneous economizer and compressor operation.

2) Independent modules for vertical or horizontal return configuration shall be available. Vertical return modules shall be available as a factory-installed option.

3) Damper blades shall be galvanized steel with composite gears. Plastic or composite blades on intake or return shall not be acceptable.

4) Shall include all hardware and controls to provide free cooling with outdoor air when temperature and/or humidity are below setpoints.

5) Shall be equipped with gear driven dampers for both the outdoor ventilation air and the return air for positive air stream control.

6) Standard leak rate shall be equipped with dampers not to exceed 2% leakage at 1 in. wg pressure differential.

7) Economizer controller RTU Open controller shall be a 4-20mA design controlled directly by the RTU Open controller. RTU Open controller meets California Title 24 Fault Detection and Diagnostic (FDD) requirements.

8) Shall be capable of introducing up to 100% outdoor air.

9) Shall be equipped with a barometric relief damper capable of relieving up to 100% return air and contain seals that meet ASHRAE 90.1-2013 requirements.

10) Shall be designed to close damper(s) during loss-of-power situations with spring return built into motor.

11) Dry bulb outdoor air temperature sensor shall be provided as standard. Enthalpy sensor is also available on factory-installed only. Outdoor air sensor setpoint shall be adjustable and shall range from 40 to 100°F (4 to 38°C). Additional sensor options shall be available as accessories.

12) The economizer controller shall also provide control of an accessory power exhaust unit function. Factory set at 100%, with a range of 0% to 100%.
13) The economizer shall maintain minimum airflow into the building during occupied period and provide design ventilation rate for full occupancy.

14) Dampers shall be completely closed when the unit is in the unoccupied mode.

15) Economizer controller shall accept a 2-10 Vdc CO2 sensor input for IAQ/DCV control. In this mode, dampers shall modulate the outdoor air damper to provide ventilation based on the sensor input.

16) Compressor lockout temperature on W7220 is adjustable from -45°F to 80°F, set at a factory default of 32°F. Others shall open at 35°F (2°C) and close at 50°F (10°C).

17) Actuator shall be direct coupled to economizer gear. No linkage arms or control rods shall be acceptable.

18) Economizer controller shall provide indications when in free cooling mode, in the DCV mode, or the exhaust fan contact is closed.

b. Head Pressure Control Package

1) Controller shall control coil head pressure by condenser fan speed modulation or condenser fan cycling and wind baffles.

2) Shall consist of solid state control and condenser coil temperature sensor to maintain condensing temperature between 90°F (32°C) and 110°F (43°C) at outdoor ambient temperatures down to -20°F (-29°C).

c. Unit Mounted, Non-Fused Disconnect Switch

1) Switch shall be factory-installed, internally mounted.

2) National Electric Code (NEC) and UL approved non-fused switch shall provide unit power shutoff.

3) Shall be accessible from outside the unit

4) Shall provide local shutdown and lockout capability.

5) Sized only for the unit as ordered from the factory. Does not accommodate field-installed devices.

d. Roof Curbs (Vertical)

1) Full perimeter roof curb with seismic isolators (2” static deflection).
2) Formed galvanized steel with wood nailer strip and shall be capable of supporting entire unit weight.

3) Permits installation and securing of ductwork to curb prior to mounting unit on the curb.

e. Medium and High Static Indoor Fan Motor(s) and Drive(s) (04-12):

1) Medium and high static motor(s) and drive(s) shall be factory-installed to provide additional performance range.

f. Outdoor Air Enthalpy Sensor:

1) The outdoor air enthalpy sensor shall be used to provide single enthalpy control. When used in conjunction with a return air enthalpy sensor, the unit will provide differential enthalpy control. The sensor allows the unit to determine if outside air is suitable for free cooling.

g. Return Air Enthalpy Sensor:

1) The return air enthalpy sensor shall be used in conjunction with an outdoor air enthalpy sensor to provide differential enthalpy control.

h. Time Guard

1) Shall prevent compressor short cycling by providing a 5-minute delay (±2 minutes) before restarting a compressor after shutdown for any reason.

2) One device shall be required per compressor.

i. Electric Heat

1) Heating Section

a) Heater element open coil resistance wire, nickel-chrome alloy, 0.29 inches inside diameter, strung through ceramic insulators mounted on metal frame. Coil ends are staked and welded to terminal screw slots.

b) Heater assemblies are provided with integral fusing in the single point box (if applicable) for protection of internal heater circuits not exceeding 48 amps each. All heaters use magnetic heater contactors (24 v coil) and terminal block all mounted in electric heater control box (minimum 18 ga galvanized steel) attached to end of heater assembly.

j. Hinged Access Panels
PART 3 - EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Provide for connection to electrical service.

C. Install all control accessories.

3.02 MANUFACTURERS FIELD SERVICES

A. Furnish a factory trained service technician to mechanically start the units. Technician will perform start-up service during regular working hours.

B. Provide training on RTU operation for facility service personnel (not to exceed 4 hours). Training shall be provided by factory-approved service engineer and will occur during regular working hours.

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY

A. Related Documents:

1. Drawings and general provisions of the Subcontract apply to this Section.

2. Review these documents for coordination with additional requirements and information that apply to work under this Section.

B. Section Includes:

1. Water coils.

2. Coil piping and accessories.

C. Related Sections:

1. Agreement for Mechanical and Control Design-Build Project

2. Division 23 Section "Air Handling and Fan Coil Units".

1.02 REFERENCED STANDARDS

A. General:

1. The following documents form part of the Specifications to the extent stated. Where differences exist between codes and standards, the one affording the greatest protection shall apply.

2. Unless otherwise noted, the referenced standard edition is the current one at the time of commencement of the Work.

3. Refer to Agreement for Mechanical and Control Design-Build Project.

4. Refer to Division 23 Section "Common Results for HVAC" for codes and standards, and other general requirements.

B. Air Conditioning and Refrigeration Institute ARI 410 Forced-Circulation Air Cooling and Air Heating Coils.
1.03 SUBMITTALS
   A. Submit under provisions of Division 23 Section "Common Results for HVAC, Review of Materials and Agreement for Mechanical and Control Design-Build Project Section "General Requirements."
   B. Submit manufacturer’s installation instructions.
   C. Submit manufacturer’s descriptive literature, operating instructions, and maintenance and repair data.

1.04 QUALITY ASSURANCE
   A. Certify that coil capacities, pressure drops, and selection procedures are in accordance with ARI 410.
   B. Coils shall be the product of manufacturer regularly engaged in production of coils who issues complete catalog data on such products.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS
   A. Aerofin, Daikin, Russell Coil, or Trane.
   B. This item is proprietary, to match existing site-wide standard and no substitution will be allowed.

2.02 FABRICATION
   A. Provide extended-surface type coils with tubes of copper or brass, and plate or helical fins of copper.
   B. Space fins 14 per inch (25 mm) maximum. Helical fins may be crimped.
   C. Maximum Face Length, 10 feet (3 m) per section.
   D. Mount air handling unit coil section in stainless steel casing designed for bolting to other sections or ductwork.

2.03 WATER HEATING COILS
   A. Design for 200 psig (1380 kPa) and 220 deg F (104 deg C).
   B. Fabricate coil headers from cast iron, copper tube, or steel pipe.

2.04 COOLING COILS
   A. Design for 200 psig (1380 kPa) and 200 deg F (102 deg C).
B. Provide moisture eliminator of 24-gage (0.70 mm) stainless steel when air velocity exceeds 500 ft/min (150 m/min).

C. Provide drip pan and drain connection for each field-assembled coil section. Fabricate drain pan from 20-gage Type 304 stainless steel. Extend 3 inches (75 mm) from face of coil entering-air side, 6 inches (150 mm) from face of coil leaving-air side, 4 inches (100 mm) from face of eliminators.

D. Fabricate coil headers from cast iron, copper tube, or steel pipe.

E. Provide cleanable coils fabricated with straight tubes and copper headers or cleanout plugs in return bend at end of each return.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Support coil sections on steel-channel or double-angle frames and secure to casings. Arrange supports for cooling coils to avoid piercing or short circuiting drip pans. Bolt casings to other section, ductwork, or unit casings. Provide airtight seal between coil and duct or unit cabinets.

B. Make connections to coils, including valves, air vents, unions, and connections, from drip pans. Pipe coil as indicated on the drawings. Pre-manufactured coil piping kits/valve assembly are not acceptable.

C. Locate water supply at bottom of supply header and return water connection at top to provide self-venting and reverse return arrangement. Provide float-operated automatic air vents at high points, complete with stop valve. Ensure that water coils are drainable and make drain connection at low points.

D. Protect coils so that fins and flanges are not damaged. Replace loose and damaged fins. Comb-out bent fins.

E. Level serpentine coils and install cleanable-tube coils and steam coils with 1:50 pitch.

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY

A. Furnish all labor, materials, equipment, and service necessary for a complete and operating HVAC Control System (BAS), utilizing Direct Digital Controls as shown on the drawings and as described herein. Drawings are diagrammatic only. Work shall include the provision of new network controllers, unit controllers, and all field devices as described on the drawings and specifications, upgrade of software, reprogramming and update of system graphics on the central operator's work station.

B. All labor, material, equipment and software not specifically referred to herein or on the plans, that is required to meet the functional intent of this specification, shall be provided without additional cost to the Owner.

C. The Design Builder performing this scope of work is referred to as the BAS Design Builder.

D. The Owner will provide IT access points in all buildings for use by the BAS Design Builder. Coordinate system requirements with the Owner. The BAS Design Builder is responsible for all wiring from the IT switch to the BAS controller.

E. Provide a system architecture that shows all components schematically from the field devices, such as actuators and sensors to the point of connection on the Owner provided IT network, with the bid documents.

F. Control system sequences of operation shall follow ASHRAE Guideline 36P as much as practicable. Shown in this section are minimum requirements. Provide additional devices, sensors, etc. to meet the intent of the control specifications and system operations.

1.02 SYSTEM DESCRIPTION

A. Vendor shall be Andover Continuum for the Diablo Valley College campus, and ALC for the Contra Costa College campus, to match the existing campus BAS.

B. New BAS shall be able to interface with the existing BAS without the use of a separate gateway.

C. Provide interface to all sub-control systems through LonWork, BACnet, Modbus, or a third party gateway as required to establish two-way communications. All points from the sub-control system(s) shall be included in the graphic interface.

D. The Design Builder can submit an alternate BAS system, which can be fully integrated with the college BAS system, along with the Base Bid for the Owner's consideration.
1.03 SUBMITTALS

A. Prior to the start of system installation, six copies of the following shall be submitted and approved. Provide six hard copies and pdf copies for all items submitted:

1. Shop drawings of the entire control system and a complete list of equipment and materials, including manufacturers catalog data sheets and installation instructions. Shop drawings shall contain complete wiring and schematic diagrams, software descriptions, calculations, and any other details required to demonstrate that the system has been coordinated and will properly function as a system. Terminal identification for all control wiring shall be shown on the shop drawings.

2. A complete written Sequence of Operation for all systems. Those sequences may be modified and altered by any of the Owner's consultants to incorporate the most advanced sequences possible for the equipment controlled. See also section 4 of this specification.

3. A complete points list for all connected points to the BAS system including proposed set-points and parameters available on the GUI.

4. To scale floor drawings that show the location of all controls devices including such items as building pressure sensors, duct pressure sensors, room sensors, valves, dampers and any other device monitored or controlled by the BAS system.

5. Control system Checkout, Testing and Demonstration forms developed in a format that fully documents the requirements as stated in “Checkout and Testing” and “Demonstration”. The forms shall include sections for any global or application programming performed by the Network Area Controllers.

6. The submittal shall also include a copy of each of the graphics developed for the local Graphic User Interface including a flowchart (site map) indicating how the graphics are intended to be linked to one another for system navigation. The graphics are intended to be 80% - 90% complete at this stage with the only remaining changes to be based on review comments from the A/E design team and/or Owner. See also section 3 of this document for further information about the content to be provided.

7. Provide a sample of all logs to be provided under section 3.14 to the satisfaction of the Owner and its representatives.

8. The submittal shall identify all Owner required IT access points to identify at least where and how many IP access points will be required.

9. Provide a spare parts submittal as defined in section 2.25.

10. Provide an alarm notification and escalation plan that includes all alarms and their notification schemes for all application and system alarms. The plan shall include all alarm points, their class, priority and their point(s) of annunciation such as email, page and visual data archive points such as printers and logs. As a minimum the following alarms shall be implemented:
a. Status alarm for all devices that have a Start/Stop and Status. The alarms shall cover any discrepancy in status for more than a specified time period. The time period shall be appropriate for the application.

b. Any Set-points not met by a selectable deviation (either in % of full range or absolute value) for more than a specified time period. The time period shall be appropriate for the application.

c. Discrete Alarm Points, shown on the points list

d. The alarms with the highest priority shall remain on top of the list.

1.04 DIVISION OF WORK

A. The controls Design Builder shall be responsible for all controllers, control devices, control panels, controller programming, controller programming software, controller input/output and power wiring, controller network wiring, control power transformers, and Portable Operator’s Terminals. This includes the 120 VAC power to the control panels. Breakers to be provided at the closest power distribution panel by Division 26.

1.05 RELATED WORK SPECIFIED ELSEWHERE

A. Division 26, Electrical:

1. Providing motor starters and disconnect switches (unless otherwise noted).

2. Power wiring and conduit (power to the control panels by BAS Design Builder if not provided by Division 26).

3. Provision, installation and wiring of smoke detectors (I/O wiring to the BAS by controls Design Builder).

1.06 CODES AND STANDARDS

A. All work, materials, and equipment shall comply with the rules and regulations of all codes and ordinances of the local, state, and federal authorities. Such codes, when more restrictive, shall take precedence over these plans and specifications. As a minimum, the installation shall comply with the current editions in effect 30 days prior to receipt of bids of the following codes. Systems or products not currently offering the following approvals are not acceptable.

1. Underwriters Laboratories UL-916; Energy Management Systems (Canada and the U.S.)

2. Occupational Safety and Health Act (OSHA)

3. National Fire Protection Association (NFPA) Standards

5. Uniform Building Code (UBC)

6. Uniform Mechanical Code (UMC)

7. Uniform Plumbing Code

8. Institute of Electrical and Electronic Engineers (IEEE)


10. LonMark® Interoperability Association’s LonMark® Certification


12. Underwriters Laboratories UL-864; Smoke Management Systems (If required by application, all costs to accommodate the listing requirement to be included in the scope of work).

1.07 OWNERSHIP OF MATERIAL

A. The Owner shall receive ownership of all job specific software configuration documentation, data files, and application-level software developed for the project. This shall include all custom, job specific software code and documentation for all configuration and programming that is generated for a given project and/or configured for use within Network Area Controllers, Web server(s), and any related LAN / WAN / Intranet and Internet connected routers and devices. Any and all required IDs and passwords for access to any component or software program shall be provided to the Owner.

1.08 DELIVERY, STORAGE AND HANDLING

A. Provide factory-shipping cartons for each piece of equipment and control device. Maintain cartons through shipping, storage, and handling as required to prevent equipment damage. Store equipment and materials inside and protected from weather.

1.09 JOB CONDITIONS

A. Cooperation with Other Trades: Coordinate the Work of this section with that of other sections to ensure that the Work will be carried out in an orderly manner. It shall be the Design Builder’s responsibility to check the Contract Documents for possible conflicts between his work and that of other crafts in equipment location, pipe, duct and conduit runs, electrical outlets and fixtures, air diffusers, and structural and architectural features.
1.10 DEFINITIONS

A. Acronyms

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Definition</th>
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<tr>
<td>AAC</td>
<td>Advanced Application Controller</td>
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<td>AH</td>
<td>Air Handler</td>
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<td>AHU</td>
<td>Air Handling Unit</td>
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<td>American Society of Mechanical Engineers</td>
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<td>Building Controller</td>
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<tr>
<td>DBMS</td>
<td>Database Management System</td>
</tr>
<tr>
<td>DDC</td>
<td>Direct Digital Control</td>
</tr>
<tr>
<td>DHW</td>
<td>Domestic Hot Water</td>
</tr>
<tr>
<td>DI</td>
<td>Digital Input</td>
</tr>
<tr>
<td>DO</td>
<td>Digital Output</td>
</tr>
<tr>
<td>D-to-A</td>
<td>Digital-to-Analog</td>
</tr>
<tr>
<td>EMCS</td>
<td>Energy Management and Control System</td>
</tr>
<tr>
<td>EMT</td>
<td>Electrical Metallic Tubing</td>
</tr>
<tr>
<td>EP</td>
<td>Electro-Pneumatic</td>
</tr>
<tr>
<td>ETL</td>
<td>Edison Testing Laboratories</td>
</tr>
<tr>
<td>GUI</td>
<td>Graphical User Interface</td>
</tr>
<tr>
<td>HHD</td>
<td>Hand Held Device</td>
</tr>
<tr>
<td>HOA</td>
<td>Hand-Off-Automatic</td>
</tr>
<tr>
<td>HVAC</td>
<td>Heating, Ventilating and Air-Conditioning</td>
</tr>
<tr>
<td>HTTP</td>
<td>Hyper-Text Transfer Protocol</td>
</tr>
</tbody>
</table>
I/O | Input/output
---|---
IEEE | Institute of Electrical and Electronics Engineers
ISO | International Organization for Standardization
LAN | Local Area Network
LANID | LAN Interface Device
LCP | Lighting Control Panel
MAC | Medium Access Control
MHz | Megahertz
MS/TP | Master-Slave/Token-Passing
NEMA | National Electrical Manufacturers Association
NFPA | National Fire Protection Association
NIST | National Institute of Standards and Technology
ODBC | Open Database Connectivity
OI | Operator Interface
OWS | Operator Workstation
P | Proportional
PC | Personal Computer
PI | Proportional-Integral
PICS | Protocol Implementation Conformance Statement
PID | Proportional-Integral-Derivative
POT | Portable Operators Terminal
PTP | Point-to-Point
RAM | Random Access Memory
SOO | Sequence of Operation
SQL | Standardized Query Language
SSL | Secure Socket Layers
TAB | Test, Adjust, and Balance
TDR | Time Delay Relay
UFT | Underfloor Fan Terminal Box
UL | Underwriters’ Laboratories, Inc.
XML | Extensible Markup Language

### B. Terms

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accessible</td>
<td>Locations that can be reached with no more than a ladder to assist access and without having to remove permanent partitions or materials. Examples include inside mechanical rooms, mechanical equipment enclosures, instrument panels, and above suspended ceilings with removable tiles.</td>
</tr>
<tr>
<td>BACnet Interoperability Building Blocks</td>
<td>A BIBB defines a small portion of BACnet functionality that is needed to perform a particular task. BIBBs are combined to build the BACnet functional requirements for a device in a specification.</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>-------------------------------------------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>BACnet/BACnet Standard</td>
<td>BACnet communication requirements as defined by the latest version of ASHRAE/ANSI 135 and approved addenda.</td>
</tr>
<tr>
<td>Change of Value</td>
<td>An event that occurs when a digital point changes value or an analog value changes by a predefined amount.</td>
</tr>
<tr>
<td>Client</td>
<td>A device that is the requestor of services from a server. A client device makes requests of and receives responses from a server device.</td>
</tr>
<tr>
<td>Concealed</td>
<td>Embedded in masonry or other construction, installed in furred spaces, within double partitions, above hung ceilings, in trenches, in crawl spaces, or in enclosures.</td>
</tr>
<tr>
<td>Continuous Monitoring</td>
<td>A sampling and recording of a variable based on time or change of state (such as trending an analog value, monitoring a binary change of state).</td>
</tr>
<tr>
<td>Contract Documents</td>
<td>Specifications, drawings, and other materials provided with request for bids.</td>
</tr>
<tr>
<td>Control Systems Server</td>
<td>A computer(s) that maintains the systems configuration and programming database.</td>
</tr>
<tr>
<td>Controller</td>
<td>Intelligent stand-alone control device. Controller is a generic reference to BCs, AACs, and ASCs.</td>
</tr>
<tr>
<td>Direct Digital Control</td>
<td>Microprocessor-based control including Analog/Digital conversion and program logic.</td>
</tr>
<tr>
<td>Energy Management and Control System</td>
<td>The entire integrated management and control system.</td>
</tr>
<tr>
<td>Equal</td>
<td>Approximately equal in material types, weight, size, design, quality, and efficiency of specified product.</td>
</tr>
<tr>
<td>Exposed</td>
<td>Not installed underground or concealed.</td>
</tr>
<tr>
<td>Furnish</td>
<td>To purchase, procure, acquire and deliver complete with related accessories.</td>
</tr>
<tr>
<td>Gateway</td>
<td>Bi-directional protocol translator connecting control systems that use different communication protocols.</td>
</tr>
<tr>
<td>Hand Held Device</td>
<td>Manufacturer’s microprocessor based portable device for direct connection to a field Controller.</td>
</tr>
<tr>
<td>Inaccessible</td>
<td>Locations that do not meet the definition of accessible. Examples include inside furred walls, pipe chases and shafts, or above ceilings without removable tiles.</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Indicated, shown or noted</td>
<td>As indicated, shown or noted on drawings or specifications.</td>
</tr>
<tr>
<td>Install</td>
<td>To erect, mount and connect complete with related accessories.</td>
</tr>
<tr>
<td>Instrumentation</td>
<td>Gauges, thermometers and other devices mounted in ductwork or piping that are not a part of the EMCS.</td>
</tr>
<tr>
<td>IT LAN</td>
<td>Reference to the facility's Information Technology network, used for normal business-related e-mail and Internet communication.</td>
</tr>
<tr>
<td>LAN Interface Device</td>
<td>Device or function used to facilitate communication and sharing of data throughout the EMCS.</td>
</tr>
<tr>
<td>Local Area Network</td>
<td>Computer or control system communications network limited to local building or campus.</td>
</tr>
<tr>
<td>Master-Slave/Token Passing</td>
<td>Data link protocol as defined by the BACnet standard.</td>
</tr>
<tr>
<td>Motor Controllers</td>
<td>Starters, variable speed drives, and other devices controlling the operation of motors.</td>
</tr>
<tr>
<td>Native BACnet Device</td>
<td>A device that uses BACnet for communication. A device may also provide gateway functionality and still be described as a Native BACnet device.</td>
</tr>
<tr>
<td>Native BACnet System</td>
<td>A network composed only of Native BACnet Devices without gateways.</td>
</tr>
<tr>
<td>Open Database Connectivity</td>
<td>An open standard application-programming interface for accessing a database developed. ODBC compliant systems make it possible to access any data from any application, regardless of which database management system is handling the data.</td>
</tr>
<tr>
<td>Open Connectivity</td>
<td>OPC is an interoperability standard developed for industrial applications. OPC compliant systems make it possible to access or exchange data from any application, regardless of which database management system is handling the data.</td>
</tr>
<tr>
<td>Operator Interface</td>
<td>A device used by the operator to manage the EMCS including OWSs, POTs, and HHDs.</td>
</tr>
<tr>
<td>Operator Workstation</td>
<td>The user's interface with the EMCS system. As the EMCS network devices are stand-alone, the OWS is not required for communications to occur.</td>
</tr>
<tr>
<td>Owner</td>
<td>The Owner or their designated representatives.</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>-------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Piping</td>
<td>Pipe, tube, fittings, flanges, valves, controls, strainers, hangers, supports, unions, traps, drains, insulation and related items.</td>
</tr>
<tr>
<td>Points</td>
<td>All physical I/O points, virtual points, and all application program parameters.</td>
</tr>
<tr>
<td>Point-to-Point</td>
<td>Serial communication as defined in the BACnet standard.</td>
</tr>
<tr>
<td>Portable Operators Terminal</td>
<td>Laptop PC used both for direct connection to a controller and for remote dial up connection.</td>
</tr>
<tr>
<td>Primary Controlling LAN</td>
<td>High speed, peer-to-peer controller LAN connecting BCs and optionally AACs and ASCs.</td>
</tr>
<tr>
<td>Protocol Implementation Conformance Statement</td>
<td>A written document that identifies the particular options specified by BACnet that are implemented in a device.</td>
</tr>
<tr>
<td>Provide</td>
<td>Furnish, supply, install and connect up complete and ready safe and regular operation of particular work referred to unless specifically noted.</td>
</tr>
<tr>
<td>Reviewed, approved, or directed</td>
<td>Reviewed, approved, or directed by or to Owner’s Representative.</td>
</tr>
<tr>
<td>Router</td>
<td>A device that connects two or more networks at the network layer.</td>
</tr>
<tr>
<td>Secondary Controlling LAN</td>
<td>LAN connecting AACs and ASCs.</td>
</tr>
<tr>
<td>Server</td>
<td>A device that is a provider of services to a client. A client device makes requests of and receives responses from a server device.</td>
</tr>
<tr>
<td>Standardized Query Language</td>
<td>SQL - A standardized means for requesting information from a database.</td>
</tr>
<tr>
<td>Supervisory LAN</td>
<td>Ethernet-based LAN connecting Primary Controller LANs with each other and OWSs, CSS, and THS. See System Architecture below.</td>
</tr>
<tr>
<td>Supply</td>
<td>Purchase, procure, acquire and deliver complete with related accessories.</td>
</tr>
<tr>
<td>Trend Historian Server</td>
<td>A computer(s) that maintain(s) the database of recorded trend logs.</td>
</tr>
<tr>
<td>Wiring</td>
<td>Raceway, fittings, wire, boxes and related items.</td>
</tr>
</tbody>
</table>
1.11 COMPLETION REQUIREMENTS

A. Procedure

1. Until the documents required in this Section are submitted and approved, the system will not be considered accepted and final payment to Design Builder will not be made.

2. Before requesting acceptance of Work, submit one set of completion documents for review and approval of Owner.

3. After review, furnish quantity of sets indicated below to Owner.

B. Completion Documents

1. Operation and Maintenance (O & M) Manuals. Provide in both paper and electronic format per Paragraph 1.7C.
   a. Include all submittals (product data, shop drawings, control logic documentation, hardware manuals, software manuals, installation guides or manuals, maintenance instructions and spare parts lists) in maintenance manual.
   b. As-built versions of the submittal product data. Submittal data shall be located in tabs along with associated maintenance information.
   c. Engineering, Installation, and Maintenance Manual(s) that explain how to design and install new points, panels, and other hardware; preventive maintenance and calibration procedures; how to debug hardware problems; and how to repair or replace hardware.
   d. Complete original issue documentation, installation, and maintenance information for all third-party hardware and software provided, including computer equipment and sensors.
   e. A list of recommended spare parts with part numbers and suppliers.
   f. Operators Manual with procedures for operating the control systems, including logging on/off, alarm handling, producing point reports, trending data, overriding computer control, and changing set points and other variables.
   g. Programming Manuals with a description of the programming language, control block descriptions (including algorithms and calculations used), point
database creation and modification, program creation and modification, and use of the programming editor.

h. Recommended preventive maintenance procedures for all system components, including a schedule of tasks (inspection, cleaning, calibration, etc.), time between tasks, and task descriptions.

i. A listing and documentation of all custom software for the Project created using the programming language, including the set points, tuning parameters, and point and object database.

j. English language control sequences updated to reflect final programming installed in the EMCS at the time of system acceptance.

k. A BACnet Protocol Implementation Conformance Statement (PICS) for each type of controller and operator interface.

2. Complete original issue CDs for all software provided, including operating systems, programming language, operator workstation software, and graphics software.

3. Complete CD copy of EMCS database, user screens, setpoints and all configuration settings necessary to allow re-installation of system after crash or replacement of server, and resume operations with the EMCS in the same configuration as during owner sign-off.

4. Project Record Drawings.
   a. As-built versions of the submittal drawings in reproducible paper and electronic format per Paragraph 1.7C.
   b. As-built network architecture drawings showing all BACnet nodes including a description field with specific controller and device identification, description and location information.

5. Commissioning Reports. Completed versions of all Pre-functional, Functional, and Demonstration Commissioning Test reports, calibration logs, etc., per Paragraph 3.16B.

6. Copy of inspection certificates provided by the local code authorities.

7. Written guarantee and warranty documents for all equipment and systems, including the start and end date for each.

8. Training materials as specified herein after.

9. Contact information. Names, addresses, and 24-hour telephone numbers of Design Builders installing equipment, and the control systems and service representatives of each.
C. Format of Completion Documents

1. Provide the type and quantity of media listed in table below.

2. Project database, programming source files, and all other files required to modify, maintain, or enhance the installed system shall be provided in their source format and compiled format (where applicable).

3. Where electronic copies are specified, comply with the following:
   a. Provide in word-searchable electronic format; acceptable formats are MS Word, Adobe Acrobat (pdf), and HTML; submit other formats for review and approval prior to submission; scanned paper documents not acceptable.
   b. For submittals, provide separate file for each type of equipment.
   c. Record drawings shall be in original format per Paragraph 1.6E.2.b.10(e).
   d. Control sequences shall be in MS Word.

1.12 WARRANTY

A. At the successful completion of the final testing, commissioning, and demonstration phase in accordance with the terms of this specification, if equipment and systems are operating satisfactorily to the Owner and if all completion requirements per Paragraph 1.7B have been fulfilled, the Owner shall certify in writing that the control system has been accepted. The date of acceptance shall be the start of the warranty period.

B. Guarantee all materials, equipment, apparatus and workmanship (including programming) to be free of defective materials and faulty workmanship for the following periods from date of acceptance:

1. BCs, AACs, and ASCs: two years

2. Valve and damper actuators: five years

3. All else: one year

C. Provide new materials, equipment, apparatus and labor to replace that determined by Owner to be defective or faulty.

D. Control system failures during the warranty period shall be adjusted, repaired, or replaced at no additional cost or reduction in service to the Owner. Design Builder shall respond to the Owner’s request for warranty service within 24 hours during normal business hours.

E. Operator workstation software, project-specific software, graphic software, database software, and firmware updates that resolve known software deficiencies shall be provided at no cost to the Owner during the warranty period.
F. Sequence of operation programming bugs (both due to programming misinterpretations and sequence errors) shall be corrected and any reasonable control sequence changes required to provide proper system operation shall be provided at no additional cost to the Owner during this period.

PART 2 - PRODUCTS

2.01 MANUFACTURER

A. Andover Continuum for Diablo Valley College
B. Automated Logic Control for Contra Costa College
C. No equal.

2.02 SYSTEM ARCHITECTURE

A. General: The Building Automation System (BAS) shall consist of Network Control Units, a family of Standalone Digital Control Units, 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. Operator's workstation and file server are existing.

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.

C. Level 2 Network Description: 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:

1. An RS485, token passing bus that supports up to 127 Standalone Digital Control Units for operation of HVAC equipment and lighting, or

2. An RS485 field bus that supports up to 32 devices from a family of plug-in, IOU modules. 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 College 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 College 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 College’s Information Systems Department as all devices utilize standard TCP/IP components.

F. Remote Communications: In addition to the above LAN/WAN architecture support, the same workstation software (front end) must be capable of managing remote systems via standard dial-up phone lines as a standard component of the software. Front-end “add-on” software modules to perform remote site communication shall not be acceptable. The remote system architecture shall consist of two levels providing control, alarm detection, reporting and information management for the remote facility. Level 1 shall contain the Remote Site Control Unit, communicating to the remotely located, Operator Workstation(s) through the use of a modem and a standard dial-up phone line. Level 2 shall consist of one or more field buses controlled by the RSCU. The field buses may consist of one or both of two types:

1. An RS485, token passing bus that supports up to 127 Standalone Digital Control Units (SDCUs) for operation of HVAC equipment and lighting, or

2. An RS485 field bus that supports up to 32 devices from a family of plug-in, IOU modules that may be mounted within the RSCU enclosure or remotely mounted on a single, twisted, shielded pair of wires.

G. System Expansion: 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. 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. IOU modules or stand-alone digital control units shall be added to the existing Level 1 controllers, field bus(es), to perform security and access applications. In this way, an College’s existing investment in wiring infrastructure may be leveraged and the cost and inconvenience of adding new field bus wiring will be minimized. 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. 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.

H. Support For Open Systems Protocols: The BAS design must include solutions for the integration of the following “open systems” protocols: BACnet, LonTalk, and digital data communication to third party microprocessors such as chiller controllers, fire panels and variable frequency drives (VFDs). 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.

2.03 NETWORK CONTROL UNITS (NCUS)

A. General: 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. NCUs for telephone dial-up 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 dial-up site.

B. Web Server Functionality: 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, Netscape Navigator, etc.) to access real-time data from the entire BAS via any NCUs. 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. 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 BMS has knowledge of, regardless of where the point is connected on the BAS network or where it is acquired from. 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 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.

2. 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).

3. Input/Output (I/O): 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.

4. 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.

5. Hardware Override Switches: All digital output units shall include three position manual override switches to allow selection of the ON, OFF, or AUTO output state. Switches shall be built into the unit or external to and shall provide feedback to the controller so that the position of the override switch can be obtained through software. In addition each analog output shall be equipped with an override potentiometer to allow manual adjustment of the analog output signal over its full range, when the 3 position manual override switch is placed in the ON position.

6. Local Status Indicator Lamps: Provide as a minimum LED indication of CPU status, Ethernet LAN status, and field bus status. For each output, provide LED indication of the value of the output (On/Off). For each output module provide an LED which gives a visual indication of whether any outputs on the module are manually overridden.

7. 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.

8. 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).

9. 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.
10. 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 modern power. This power backup system shall be configurable such that at the end of a settable time frame (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.

D. Software Specifications

1. General. The NCU shall contain flash ROM as the resident operating system. Application software will be RAM resident. Application software will only be limited by the amount of RAM memory. There will be no restrictions placed on the type of application programs in the system. Each NCU shall be capable of parallel processing, executing all control programs simultaneously. Any program may affect the operation of any other program. Each program shall have the full access of all I/O facilities of the processor. This execution of control function shall not be interrupted due to normal user communications including interrogation, program entry, printout of the program for storage, etc.

2. 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 structured 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.

E. 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
   f. Equipment Cycling Protection

2. 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.

3. Energy Management Applications: 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)
i. Peak Demand Limiting
j. Temperature Compensated Duty Cycling
k. CFM Tracking
l. Heating/Cooling Interlock
m. Hot/Cold Deck Reset
n. Free Cooling
o. Hot Water Reset
p. Chilled Water Reset
q. Condenser Water Reset
r. Chiller Sequencing

4. 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.

5. Alarm Management: For each system point, alarms can be created based on high/low limits or conditional expressions. All alarms shall be tested each scan of the NCU and can result in the display of one or more alarm messages or reports. Up to 8 alarms can be configured for each point in the controller. Messages and reports can be sent to a local terminal, to the front-end workstation(s), or via modem to a remote-computing device. 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.

6. 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.

2.04 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: Each SDCU shall support the addition of the following types of inputs and outputs:

1. Digital Inputs for status/alarm contacts
2. Counter Inputs for summing pulses from meters.
3. Thermistor Inputs for measuring temperatures in space, ducts and thermowells.
4. Analog inputs for pressure, humidity, flow and position measurements.
5. Digital Outputs for on/off equipment control.
6. 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: 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. 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. Alarm messages can be sent to a local terminal or modem connected to an NCU or to the Operator’s Workstation(s). Alarms will be generated based on their priority. A minimum of 255 priority levels shall be provided. 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): 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. AHU Controllers shall support all the necessary point inputs and outputs as required by the sequence and operate in a standalone fashion. AHU Controllers shall be fully user programmable to allow for modification of the application software. An LCD display shall be optionally available for readout of point values and to allow operators to change setpoints and system parameters. 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. VAV Terminal Unit Controllers: VAV Terminal Unit Controllers shall support, but not be limited to the control of the following configurations of VAV boxes to address current requirements as described in the Execution portion of this specification, and for future expansion:

1. Single Duct Cooling Only
2. Single Duct Cooling with Reheat (Electric or Hot Water)
3. Fan Powered (Parallel or Series)
4. Supply/Exhaust
5. VAV Controllers for single duct applications will come equipped with a built-in actuator for modulation of the air damper. The actuator shall have a minimum torque rating of 35 in.-lb., and contain an override mechanism for manual positioning of the damper during startup and service. VAV Controllers shall contain an integral velocity sensor accurate to +/- 5% of the full range of the box’s CFM rating. Each controller shall perform the sequence of operation described in Part 3 of this specification, and have the capability for time of day scheduling, occupancy mode control, after hours operation, lighting control, alarming, and trending. VAV Controllers shall be able to communicate with any other Standalone Digital Control Unit on the same field bus with or without communication to the NCU managing the field bus. Systems that fail to provide this (true peer-to-peer) capability will be limited to a maximum of 32 VAV controllers per field bus.

N. Unitary Controllers: Unitary Controllers shall support, but not be limited to, the control of the following systems as described in the Execution portion of this specification, and for future expansion:

1. Unit Ventilators
2. Heat Pumps (Air to Air, Water to Water)
3. Packaged Rooftops
4. Fan Coils (2 or 4 Pipe)
5. The I/O of each Unitary Controller shall contain the sufficient quantity and types as required to meet the sequence of operation found in the Execution portion of this specification. In addition, each controller shall have the capability for time of day scheduling, occupancy mode control, after hour operation, lighting control, alarming, and trending.
2.05 MODBUS SYSTEM INTEGRATION

A. The preferred means of integrating data from a third-party product into the BAS will be a MODBUS interface.

B. The Network Area Controller shall support the integration of device data from Modbus RTU, ASCII, or TCP control system devices. The connection to the Modbus system shall be via an RS-232, RS-485, or Ethernet IP as required by the device.

C. Provide the required objects in the library, included with the Graphical User Interface programming software, to support the integration of the Modbus system data into the BAS. Objects provided shall include at a minimum:

1. Read/Write Modbus AI Registers
2. Read/Write Modbus AO Registers
3. Read/Write Modbus BI Registers
4. Read/Write Modbus BO Registers

D. All scheduling, alarming, logging and global supervisory control functions, of the Modbus system devices, shall be performed by the Network Area Controller.

E. The equipment system vendor that provided the equipment utilizing Modbus shall ensure that the existing system’s database is setup to make all data to be integrated into the BAS available at the interface. Any modifications to the existing system database to accomplish this shall be the responsibility of the equipment system vendor that provided the equipment utilizing Modbus.

F. The BAS supplier shall provide a Modbus system communications driver. The equipment system vendor that provided the equipment utilizing Modbus shall provide documentation of the system’s Modbus interface and shall provide factory support at no charge during system commissioning.

2.06 VFD DRIVE CONTROL AND MONITORING (VFD)

A. These points shall be hard wired from the new control system to the VFD’s. The control signal for the VFD shall be wired directly to the controller controlling the VFD. Do not use the BAS network to communicate the control signal from the source to the controller

1. VFD Enable
2. Commanded Speed in either Hz or percent of full speed

B. The general alarm shall include any alarm that will cause the drive to stop running.
C. All VFD’s shall also be connected thru a serial connection and provide all available information to the BAS. For additional information see section 4. Provide a suggested point mapping list during the submittal phase. As a minimum the following points shall be available.

1. VFD Status On/Off R Privileges
2. VFD Alarm Nml/Alm R Privileges
3. Actual Speed % and Hz R Privileges
4. Commanded Speed % and Hz R Privileges
5. Energy Consumption kWh R Privileges
6. Amperage Amp R Privileges
7. Energy Demand KW R Privileges
8. motor Speed RPM R Privileges

2.07 ELECTRIC WIRING DEVICES

A. All electrical work shall comply with Division 26.

B. Communication Wiring

1. Provide all communication wiring between Building Controllers, Routers, Gateways, AACs, ASCs and local and remote peripherals (such as operator workstations and printers).

2. Ethernet LAN: Use Fiber or Category 5 or 6 of standard TIA/EIA 68 (10baseT). Network shall be run with no splices and separate from any wiring over 30 volts.

3. ARCnet and MS/TP LAN: Communication wiring shall be individually 100% shielded pairs per manufacturers recommendations for distances installed, with overall PVC cover, Class 2, plenum-rated run with no splices and separate from any wiring over 30 volts. Shield shall be terminated and wiring shall be grounded as recommended by BC manufacturer.

C. Analog Signal Wiring

1. Input and output signal wiring to all field devices, including, but not limited to, all sensors, transducers, transmitters, switches, current or voltage analog outputs, etc. shall be twisted pair, 100% shielded if recommended or required by controller manufacturer, with PVC cover. Gauge shall be as recommended by controller manufacturer.
2.08 CONTROL CABINETS

A. All control cabinets shall be fully enclosed with hinged door and slotted key-lock latch. A single key shall be common to all field panels and sub-panels within each building. Provide 3 keys.

B. Construction

1. Indoor: NEMA 1

2. Outdoor: NEMA 4

C. Interconnections between internal and face-mounted devices shall be pre-wired with color-coded stranded conductors neatly installed in plastic troughs or tie-wrapped. Terminals for field connections shall be UL Listed for service, individually identified per control-interlock drawings, with adequate clearance for field wiring. All control tubing and wiring shall be run neatly and orderly in open slot wiring duct with cover. Control terminations for field connection shall be individually identified per control Shop Drawings.

D. Provide ON/OFF power switch with over-current protection for control power sources to each local panel.

E. Provide with

1. Framed, plastic-encased point list for all points in cabinet.

2. Nameplates for all devices on face.

2.09 SENSORS AND MISCELLANEOUS FIELD DEVICES

A. The listing of several sensors or devices in this section does not imply that any may be used. Refer to points list in Paragraph 2.13 Points List for device specification. Only where two or more devices are specifically listed in points list (such as “FM-1 or FM-4”) may the Design Builder choose among listed products.

B. Control Valves

1. Manufacturers

   a. Belimo

   b. Siemens

   c. Invensys

   d. Delta

   e. Or equal

2. Plug-Type Globe
a. Valves shall have cage-type trim, providing seating and guiding surfaces for plug on top-and-bottom guided plugs.

b. Temperature Rating: 25°F minimum, 250°F maximum

c. Body: Cast Iron, flanged

d. Valve Trim: Bronze; Stem: Polished stainless steel

e. Packing: Spring Loaded Teflon or Synthetic Elastomer U-cups, self-adjusting

f. Plug: Brass, bronze or stainless steel, Seat: Brass

g. Disc: Replaceable Composition or Stainless Steel Filled PTFE

h. Ambient Operating Temperature Limits: -10 to 150°F (-12.2 to 66 °C)

3. Butterfly Type

a. Body: Extended neck epoxy coated cast or ductile iron with full lug pattern, ANSI Class bolt pattern to match specified flanges.

b. Seat: EPDM replaceable, non-collapsible, phenolic backed.

c. Disc: Polished aluminum bronze or stainless steel, pinned or mechanically locked to shaft. Sanded castings are not acceptable.

d. Bearings: Bronze or stainless steel.

e. Shaft: 416 stainless steel supported at three locations with PTFE bushings for positive shaft alignment.

f. Close Off: Bubble-tight shutoff at rated differential pressure.

g. Manufacturers (In Addition to Paragraph 2.10B.1.)

1) Jamesbury

2) Keystone

3) Dezurik

4) Or equal

4. Characterized Ball Type

a. Valves shall be specifically designed for modulating duty in control application with guaranteed average leak-free life span over 200,000 full stroke cycles.
b. Industrial quality with nickel plated forged brass body and female NPT threads.

c. Blowout proof stem design, glass-reinforced Teflon thrust seal washer and stuffing box ring with minimum 600 psi rating (2-way valves) or 400 psi rating (3-way valves). The stem packing shall consist of 2 lubricated O-rings designed for on-off, floating, or modulating service and requiring no maintenance.

d. Valves suitable for water or low-pressure steam shall incorporate an anti-condensation cap thermal break in stem design.

e. Ball: stainless steel.

f. Stem: stainless steel.

g. Characterizing disk held securely by a keyed ring providing equal percentage characteristic.

5. Pressure Independent Control Valve

a. Manufacturers

1) Danfoss

2) Belimo

3) Bell & Gossett

4) Delta-P

5) Griswold

b. The modulating control valves shall be pressure independent.

1) The flow through the valve shall not vary more than ± 5% due to system pressure fluctuations across the valve in the selected operating range.

2) The control valves shall accurately control the flow from 0 to 100% full rated flow.

3) The valve shall have an equal percentage characteristic.

c. No more than 5 psi differential pressure shall be required to operate the valve pressure independently.

d. Valves shall require no maintenance and shall not include replaceable cartridges.
e. Include pressure and temperature (P/T) ports for flow or temperature measurement.

6. Minimum valve assembly pressure ratings
   a. Chilled water: 125 psi at 60°F
   b. Hot water: 125 psi at 200°F
   c. Condenser water: 125 psi at 60°F

7. Valve Selection
   a. Valve type
      1) Modulating 2-way or 3-way valves
         a) 3 inch and less: characterized ball type
         b) 4 inch and greater: globe type
      2) Bypass valve at primary-only variable flow pumping system outlet: Pressure independent globe type.
      3) Chiller head pressure control: butterfly
      4) Tower bypass: butterfly
      5) Two-position isolation: butterfly or ball valves
   b. Valve Characteristic
      1) 2-way valves: equal percentage or modified equal percentage.
      2) 3-way valves controlling cooling coils and condenser water heat exchangers: linear.
      3) 3-way valves controlling heating coils: equal percentage or modified equal percentage.
      4) Two-position valves: not applicable. For ball valves used for two-position duty, do not include characterizing disk.
   c. Valve Sizing
      1) See schedule on plans.
      2) Modulating Water: Size valve to achieve the following full-open pressure drop
         a) Minimum pressure drop: equal to half the pressure drop of coil or exchanger.
b) Maximum pressure drop
   i) Hot water at coils: 2 psi
   ii) Chilled water at coils: 5 psi
   iii) Chiller head pressure control: 1 psi

c) 3-way valves shall be selected for near minimum pressure drop. 2-way valves shall be selected near maximum pressure drop.

d) Flow coefficient ($C_v$) shall not be less than 1.0 (to avoid clogging) unless protected by strainer.

3) Two-position valves: Line size unless otherwise indicated on Drawings.

4) Pressure independent valves: Line-size with flow limiting device selected for design flow.

C. Actuators

1. Manufacturers
   a. Belimo
   b. Siemens
   c. Johnson Controls
   d. Delta
   e. Invensys
   f. Or equal

2. Warranty: Valve and damper actuators shall carry a manufacturer's 5-year warranty.

3. Electric Actuators
   a. Entire actuator shall be UL or CSA approved by a National Recognized Testing Laboratory.
   b. Enclosure shall meet NEMA 4X weatherproof requirements for outdoor applications.
   c. Dampers. The actuator shall be direct coupled over the shaft, enabling it to be mounted directly to the damper shaft without the need for connecting linkage. The clamp shall be steel of a V-bolt design with associated V-shaped, toothed cradle attaching to the shaft for maximum strength and eliminating slippage via cold weld attachment. Single bolt or set screw type fasteners are not acceptable. Aluminum clamps are unacceptable.
d. Valves. Actuators shall be specifically designed for integral mounting to valves without external couplings.

e. Actuator shall have microprocessor based motor controller providing electronic cut off at full open so that no noise can be generated while holding open. Holding noise level shall be inaudible.

f. Noise from actuator while it is moving shall be inaudible through a tee-bar ceiling.

g. Actuators shall provide protection against actuator burnout using an internal current limiting circuit or digital motor rotation sensing circuit. Circuit shall insure that actuators cannot burn out due to stalled damper or mechanical and electrical paralleling. End switches to deactivate the actuator at the end of rotation or use of magnetic clutches are not acceptable.

h. Modulating Actuators

1) General: Actuators shall accept a 0 to 10 VDC or 0 to 20 mA control signal and provide a 2 to 10 VDC or 4 to 20 mA operating range. Actuators shall have positive positioning circuit so that controlled device is at same position for a given signal regardless of operating differential pressure. Actuators that internally use a floating actuator with an analog signal converter are not acceptable.

2) Optional for VAV box dampers only: Actuators may be floating type if either:
   a) Feedback from the actuator is provided as an analog input; or
   b) For VAV boxes not serving areas occupied 24 hours per day, damper position is estimated by timing pulse-open and pulse-closed commands with auto-zeroing whenever zone is in Unoccupied mode and damper is driven full closed.

i. Where indicated on Drawings or Points List, actuators shall include

1) 2 to 10 VDC position feedback signal

2) Limit (end) position switches

j. All 24 VAC/DC actuators shall operate on Class 2 wiring and shall not require more than 10 VA for AC. Actuators operating on 120 VAC power shall not require more than 10 VA. Actuators operating on 230 VAC power shall not require more than 11 VA.

k. All modulating actuators shall have an external, built-in switch to allow the reversing of direction of rotation.
l. Actuators shall be provided with a conduit fitting an a minimum three-foot electrical cable and shall be pre-wired to eliminate the necessity of opening the actuator housing to make electrical connections.

m. Where fail-open or fail-closed position is required, an internal mechanical, spring return mechanism shall be built into the actuator housing. Non-mechanical forms of fail-safe are not acceptable. All spring return actuators shall be capable of both clockwise or counterclockwise spring return operation by simply changing the mounting orientation.

n. Actuators shall be capable of being mechanically and electrically paralleled to increase torque where required.

o. All non-spring return actuators shall have an external manual gear release to allow manual positioning of the damper when the actuator is not powered. Spring return actuators with more than 60 inch-pound torque capacity shall have a manual crank for this purpose.

p. Actuators shall be designed for a minimum of 60,000 full cycles at full torque and be UL 873 listed.

q. Actuators shall clearly indicate position of damper/valve.

4. Electric Actuators for Large Butterfly Valve

a. Entire actuator shall be UL or CSA approved by a National Recognized Testing Laboratory.

b. The valve actuator shall consist of a capacitor-type reversible electric motor, gear train, limit switches and terminal block, all contained in a die cast aluminum enclosure.

c. Enclosure shall meet NEMA 4X weatherproof requirements for outdoor applications.

d. Output shaft shall be electroless nickel plated to prevent corrosion.

e. Actuator shall have a motor rated for minimum 75% duty cycle. Duty cycle shall be defined as running time divided by installed time at maximum torque.

f. Actuator shall be suitable for operation in ambient temperature ranging from -22°F to+150°F (-30°C to +65°C).

g. A pre-wired cable shall bring wiring outside enclosure to avoid necessity of opening cover.

h. Gears shall be hardened alloy steel, permanently lubricated. A self-locking gear assembly or a brake shall be supplied.
i. Actuator shall be equipped with a hand wheel for manual override to permit operation of the valve in the event of electrical power failure or system malfunction. Hand wheel must be permanently attached to the actuator. When in manual operation electrical power to the actuator will be permanently interrupted.

j. The hand wheel will not rotate while the actuator is electrically driven.

k. Actuator shall have heater and thermostat to minimize condensation within the actuator housing.

l. Provide limit (end) position switches where indicated on schematics.

5. Normal Position. Except as specified otherwise herein, the requirement for spring return actuators and the normal positions of control devices shall be as indicated in table below. For actuators indicated as Spring Return Required in the table, normal position refers to the position with zero control signal and with no power to the actuator. For actuators not indicated as Spring Return Required in the table, non-spring style actuators are acceptable and normal position refers to the position with zero control signal.

<table>
<thead>
<tr>
<th>Device</th>
<th>Normal Position</th>
<th>Spring Return Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outside air damper</td>
<td>CLOSED</td>
<td>Yes</td>
</tr>
<tr>
<td>Return air damper</td>
<td>OPEN</td>
<td>Yes</td>
</tr>
<tr>
<td>Exhaust/relief air damper</td>
<td>CLOSED</td>
<td>Yes</td>
</tr>
<tr>
<td>Domestic hot water generator</td>
<td>CLOSED</td>
<td>Yes</td>
</tr>
<tr>
<td>AHU heating coil valves</td>
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</tr>
<tr>
<td>AHU cooling coil valves</td>
<td>CLOSED</td>
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<tr>
<td>Equipment isolation valves</td>
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<td></td>
</tr>
<tr>
<td>Hot water reheat coil valves</td>
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<td></td>
</tr>
<tr>
<td>Fan-coil HW and CHW valves</td>
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<td></td>
</tr>
<tr>
<td>CRAC CHW valves</td>
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<td></td>
</tr>
<tr>
<td>VAV box dampers</td>
<td>OPEN</td>
<td></td>
</tr>
</tbody>
</table>

6. Valve Actuator Selection

a. Modulating actuators for valves shall have minimum range ability of 50 to 1.

b. Water

1) 2-way and two-position valves
   a) Tight closing against 125% of system pump shut-off head.
   b) Modulating duty against 90% of system pump shut-off head.
2) 3-way shall have close-off against twice the full open differential pressure for which they are sized.

7. Damper Actuator Selection
   a. Actuators shall be direct coupled. For multiple sections, provide one actuator for each section; linking or jack-shafting damper sections shall not be allowed.
   b. Provide sufficient torque as velocity, static, or side seals require per damper manufacturer’s recommendations and the following:
      1) Torque shall be a minimum 5 inch-pound per square foot for opposed blade dampers and 7 inch-pound per square foot for parallel blade dampers.
      2) The total damper area operated by an actuator shall not exceed 80% of the manufacturer’s maximum area rating.

D. General Field Devices
   1. Provide field devices for input and output of digital (binary) and analog signals into controllers (BCs, AACs, ASCs). Provide signal conditioning for all field devices as recommended by field device manufacturers and as required for proper operation in the system.
   2. It shall be the Design Builder’s responsibility to assure that all field devices are compatible with controller hardware and software.
   3. Field devices specified herein are generally two-wire type transmitters, with power for the device to be supplied from the respective controller. If the controller provided is not equipped to provide this power, or is not designed to work with two-wire type transmitters, or if field device is to serve as input to more than one controller, or where the length of wire to the controller will unacceptably affect the accuracy, provide four-wire type equal transmitter and necessary regulated DC power supply or 120 VAC power supply, as required.
   4. For field devices specified hereinafter that require signal conditioners, signal boosters, signal repeaters, or other devices for proper interface to controllers, furnish and install proper device, including 120V power as required. Such devices shall have accuracy equal to, or better than, the accuracy listed for respective field devices.
   5. Accuracy: As used in this Section, accuracy shall include combined effects of nonlinearity, non-repeatability and hysteresis. Sensor accuracy shall be at or better than both that specifically listed for a device and as required by Paragraph 1.8B.2.

E. Temperature Sensors (TS)
   1. General
a. Unless otherwise noted, sensors may be platinum RTD, thermistor, or other device that is commonly used for temperature sensing and that meets accuracy, stability, and resolution requirements.

b. When matched with A/D converter of BC, AAC, or ASC, sensor range shall provide a resolution of no worse than 0.3°F (0.16°C) (unless noted otherwise herein).

c. Sensors shall drift no more than 0.3°F and shall not require calibration over a five-year period.

d. Manufacturers

1) Mamac
2) Kele Associates
3) Building Automation Products Inc.
4) Automated Logic Corp.
5) Or equal

2. Duct temperature sensors: Shall consist of sensing element, junction box for wiring connections and gasket to prevent air leakage or vibration noise. Sensor probe shall be 304 stainless steel.

a. TS-1A: Single point (use where not specifically called out to be averaging in points list).

b. TS-1B: Averaging. Sensor length shall be at least 1 linear foot for each 2 square feet of face area up to 25 feet maximum.

3. Water Temperature Sensors

a. TS-2A: Well mounted immersion sensor, ¼” stainless steel probe, double encapsulated sensor, with enclosure suitable for location.

b. TS-2B: Same as TS-2A except provide extra precision (XP) temperature sensors to meet accuracy specified Paragraph 1.8B.2.

c. TS-2C. See BTU-1.

d. TS-2D. 100 Ohm platinum RTD and a solid-state 4-wire, 4-20mA transmitter contained in a housing suitable for pipe mounting, spring-loaded probe to ensure good thermal contact between the sensor and the well. Manufacturer must be certified as meeting the requirements of ISO 9001. RTD shall conform to the DIN 437601980 standards (Ultra precision DIN RTD). 2 Year NIST traceable guarantee. Manufacturer: Accutech AI-2000, or equal.
e. All piping immersion sensors shall be in one-piece machined brass or stainless steel wells that allow removal from operating system, with lagging extension equal to insulation thickness where installed in insulated piping. Wells shall be rated for maximum system operating pressure, temperature and fluid velocity. The well shall penetrate the pipe by the lesser of approximately half the pipe diameter or eight inches. The use of direct immersion or strap-on type sensors is not acceptable.

4. Room Sensors: Shall be an element contained within a ventilated cover, suitable for wall mounting, with insulated base.

a. TS-3A

1) Thermistor in enclosure with blank cover.

2) For temperature sensors connected to terminal box controllers (such as at VAV boxes) that require calibration: Include a USB port or some other means for connection of POT for terminal box calibration. Alternative means of terminal calibration are acceptable provided they result in no cost to Work performed under Section 230593 Testing, Adjusting, and Balancing.

b. TS-3B: Same as TS-3A except

1) Setpoints shall be adjustable at wall mounted sensor with setpoint knobs (with software limits and setpoint adjustment capability through the OWS).

2) Override button capable of being programmed to start system during unscheduled hours.

c. TS-3C: Same as TS-3B except integral LCD display of space temperature and active setpoint.

d. TS-3D: Same as TS-3A except flush or low profile (protruding no deeper than ¾ inch from face of wall).

e. TS-3E. “Button” temperature sensor. BAPI/LP, Titan Products TPWBS, or equal.

f. TS-3F. Radiant temperature sensor. Titan Products TPRS/BB, 4-20 mA signal.

g. See equipment schedules for thermostat type.

h. Unless otherwise indicated in points list or drawings, locate sensors as follows:

1) Lobbies, corridors, break rooms, and public spaces: TS-3A
2) Equipment rooms and other back-of-house spaces: TS-3A

3) Open offices: TS-3A.

4) Private offices: TS-3C

5) Conference rooms, meeting rooms, etc.: TS-3C

6) Classrooms, labs, training rooms, multi-purpose rooms, etc.: TS-3C

7) Others not listed: Confirm with Engineer through RFI.

5. TS-4: Outdoor Air Sensors

a. Enclose in fan-aspirated radiation shield that combines both active and passive aspiration to minimize the effects of radiation.

1) Motor-driven fan draws air through the sensor chamber and exhausts it through the top of the shield.

2) Triple-walled sensor chamber shielded by flow-through plates.

3) Aspiration rate: minimum is 220 feet per minute.

b. Sensor electronics mounted in watertight gasketed enclosure to prevent water seepage

c. Manufacturer

1) Davis Instruments

2) Met One Instruments

3) Or equal

d. Outdoor air sensors shall have a sun shield, utility box, and watertight gasket to prevent water seepage.

6. TS-5: Dewpoint

a. Industrial humidity sensor designed for applications with a risk of condensation.

b. Stainless steel probe head leak-proof up to 1 MPa.

c. Configurable to output dewpoint, relative humidity, and temperature.

d. TS-5A: Include local LCD readout.
e. Manufacturer

1) Vaisala HMT331
2) Equal (no known equal)

7. Temperature Transmitters: Where required by the Controller or to meet specified end-to-end accuracy requirements, sensors as specified above shall be matched with transmitters outputting 4-20 mA linearly across the specified temperature range. Transmitters shall have zero and span adjustments, an accuracy of 0.1°F when applied to the sensor range.

F. BTU Meter (BTU-1)

1. Matched RTD or solid state temperature sensors with a differential temperature accuracy of +/-0.15°F.
2. Flow meter: FM-1
3. Unit accuracy shall be +/- 1% factory calibrated, traceable to NIST with certification.
4. NEMA 1 enclosure.
5. UL listed.
6. I/O.
   a. Points:
      1) supply temperature
      2) return temperature
      3) flow
      4) energy rate (Btu/hr)
   b. Provide BACnet/MSTP network connection that will allow all point data to be transmitted to EMCS network.

7. Manufacturers
   a. Onicon
   b. Siemens Sitrans
   c. Or Equal

G. Pressure Transmitters (PT)
1. PT-1: Water, General Purpose
   a. Fast-response stainless steel sensor
   b. Two-wire transmitter, 4-20 mA output with zero and span adjustments
   c. Accuracy
      1) Overall Accuracy (at constant temp) ±0.5% full scale, includes non-linearity, repeatability, and hysteresis
   d. Long Term Stability 0.5% FS per year.
   e. Pressure Limits
      1) Rated pressure: see points list
      2) Proof pressure = 3x rated pressure
      3) Burst pressure = 5x rated pressure
   f. Manufacturers
      1) Setra 209
      2) Kele & Associates P51 Series
      3) Or equal

H. Differential Pressure Transmitters (DP)
1. DPT-1: Water, General Purpose
   a. Fast-response capacitance sensor
   b. Two-wire transmitter, 4-20 mA output with zero and span adjustments
   c. Accuracy
      1) Overall Accuracy (at constant temp) ±0.25% full scale (FS).
      2) Non-Linearity, BFSL ±0.22% FS.
      3) Hysteresis 0.10% FS.
      4) Non-Repeatability 0.05% FS.
   d. Long Term Stability 0.5% FS per year
e. Only 316 stainless steel in contact with fluid

f. Pressure Limits

1) 0 to 100 psid range: 250 psig maximum static pressure rating, 250 psig maximum overpressure rating.

2) 100 to 300 psid range: 450 psig maximum static pressure rating, 450 psig maximum overpressure rating.

g. Include brass 3-valve assembly. See Paragraph 3.13E.8

h. Manufacturers

1) Setra 209 or 230

2) Modus W30

3) Or equal

2. DPT-2: Not used

3. DPT-3: Air, Duct Pressure:

a. General: Loop powered two-wire differential capacitance cell-type transmitter.

b. Output: two wire 4-20 mA output with zero adjustment.

c. Overall Accuracy: ±1% scale.

d. Minimum Range: 0.5 inches water column.

e. Maximum Range: 10 inches water column.

f. Housing: Polymer housing suitable for surface mounting.

g. Static Sensing Element: Pitot-type static pressure sensing tips similar to Dwyer model A-301, Davis Instruments, or equal, with connecting tubing.

h. Range: Select as specified in points list or, if not listed for specified setpoint to be between 25% and 75% full-scale.

i. DPT-3A: Include LCD display of reading.

j. Manufacturers.

1) Setra

2) Modus
3) Invensys
4) Dwyer
5) Or equal

4. DPT-4: Air, Low Differential Pressure
   a. General: Loop powered, two-wire differential capacitance cell type transmitter.
   b. Output: Two-wire 4-20 mA output with zero adjustment.
   c. Overall Accuracy
      1) General: ±1% FS
      2) Underfloor: ±0.5% FS
      3) Minimum outdoor air damper DP used for minimum outdoor airflow: ±0.25% FS
   d. Range
      1) Non-switch selectable
      2) Minimum Range: 0, -0.1, -0.25, or -0.5 inches water column
      3) Maximum Range: +0.1, 0.25, or 0.5 inches water column
      4) Range shall be as specified in points list or, if not listed, selected such that specified setpoint is between 25% and 75% full-scale.
   e. Housing: Polymer housing suitable for surface mounting
   f. Static Sensing Element
      1) Ambient sensor: Dwyer A-306 or 420, BAPI ZPS-ACC-10, or equal
      2) Space sensor: Kele RPS-W, BAPI ZPS-ACC-01, Dwyer A-417 or 465, or equal wall plate sensor
      3) Filter or duct pressure sensor: Dwyer A-301 or equal
      4) Plenum pressure sensor: Dwyer A-421 or equal
   g. DPT-4A: Include LCD display of reading
   h. Manufacturers
5. DPT-5: VAV Velocity Pressure
   a. General: Loop powered two-wire differential capacitance cell type transmitter.
   b. Output: Two-wire, 4-20 mA output with zero adjustment.
   c. Flow transducer (including impact of A-to-D conversion) shall be capable of stably controlling to a setpoint of 0.004 inches differential pressure or lower, shall be capable of sensing 0.002 inches differential pressure or lower, and shall have a ±0.001 inches or lower resolution across the entire scale.
   d. Calibration software shall use a minimum of two field measured points, minimum and maximum airflow, with curve fitting airflow interpolation in between.
   e. Minimum Range: 0 in. water column.
   f. Maximum Range: 1.5 inch water column.
   g. Housing: Polymer housing suitable for surface mounting.
   h. Manufacturer
      1) Automated Logic
      2) Honeywell
      3) Or equal

I. Flow switch (FS-1)
   1. Calorimetric type or other device equally resistant to fouling and corrosion
   2. Shall not require more than one pipe diameter (or 12 inches whichever is larger) of straight piping for proper operation
   3. IFM or equal

J. Water Leak Detector (WLD)
1. Gold plated adjustable sensing probes to detect water from 0 to 1/8 inch above surface

2. All electronic circuitry encapsulated in epoxy to protect from dirt, fungus and short term immersion in water

3. DPDT (2 form C) relay contact outputs rated at 1amp@28 Vdc

4. Powered with 12-24 Vac or Vdc from EMCS panel. Battery not acceptable.

5. 5 year warranty minimum

6. Manufacturers
   a. Dorlen Water Alert SS-4
   b. Or equal

K. Differential Pressure Switches (DPS)
   1. DPS-1: Water: Diaphragm with adjustable setpoint, 2 psig or adjustable differential, and snap-acting Form C contacts rated for the application. 60 psid minimum pressure differential range. 0ºF to 160ºF operating temperature range.
   2. DPS-2: Air: Diaphragm with adjustable setpoint and differential and snap acting form C contacts rated for the application. Automatic reset. Provide manufacturer's recommended static pressure sensing tips and connecting tubing.

L. Current Switches (CS-1)
   1. Clamp-on or solid-core
   2. Range: as required by application
   3. Trip Point: Automatic or adjustable
   4. Switch: Solid state, normally open, 1 to 135 Vac or Vdc, 0.3 Amps. Zero off state leakage
   5. Lower Frequency Limit: 6 Hz
   6. Trip Indication: LED
   7. Approvals: UL, CSA
   8. May be combined with relay for start/stop
   9. Where used for single-phase devices, provide the CS/CR in a self-contained unit in a housing with override switch. Kele RIBX, Veris H500, or equal
10. Manufacturers
   a. Veris Industries H-608/708/808/908
   b. Veris Industries H-10F
   c. Senva C-2320L
   d. RE Technologies SCS1150A-LED
   e. Or equal

M. Current Transformers (CT)
      a. Range: 1-10 amps minimum, 20-200 amps maximum
      b. Trip Point: Adjustable
      c. Output: 0-5 VDC
      d. Accuracy: ±0.2% from 20 to 100 Hz.
      e. Manufacturers: Kele SC100, Veris 722, or equal

N. Flow Meter (FM)
   1. FM-1: Vortex shedding flow meter
      a. Output: 4-20 mA, 0-10 Vdc, 0-5 Vdc.
      c. Wetted Parts: Stainless Steel.
      d. Housing: NEMA 4X.
      e. Turndown: 25:1 minimum.
      f. Accuracy: 0.5% of calibrated span for liquids, 1% of calibrated span for steam and gases.
      g. Each sensor shall be individually factory calibrated and tagged accordingly against the manufacturer's primary standards which must be accurate to within 0.1% and traceable to the U.S. National Institute of Standards and Technology (NIST).
      h. Body: Wafer style or ANSI flanged to match piping specification.
i. Manufacturers
   1) Foxboro 83 series
   2) Rosemount 8800 Series
   3) Johnson-Yokagawa
   4) Or equal

2. FM-2: Insertion type turbine meter
   a. For pipes 2.5" and larger: Dual counter-rotating axial turbine elements, each with its own rotational sensing system, and an averaging circuit to reduce measurement errors due to swirl and flow profile distortion.
   b. For pipes 2" and smaller: Single axial turbine.
   c. Flow sensing turbine rotors shall be non-metallic and not impaired by magnetic drag.
   d. Insertion type complete with 'hot-tap' isolation valves to enable sensor removal without water supply system shutdown.
   e. Sensing method shall be impedance sensing (nonmagnetic and non-photoelectric)
   f. Volumetric accuracy
      1) ± 0.5% of reading at calibrated velocity
      2) ± 1% of reading from 3 to 30 ft/s (10:1 range)
      3) ± 2% of reading from 0.4 to 20 ft/s (50:1 range)
   g. Each sensor shall be individually factory calibrated and tagged accordingly against the manufacturer’s primary standards which must be accurate to within 0.1% and traceable to the U.S. National Institute of Standards and Technology (NIST).
   h. Maximum operating pressure of 400 psi and maximum operating temperature of 200°F continuous (220°F peak).
   i. All wetted metal parts shall be constructed of 316 stainless steel.
   j. Analog outputs shall consist of non-interactive zero and span adjustments, a DC linearly of 0.1% of span, voltage output of 0-10 V, and current output of 4-20 mA.
**k. Manufacturers:**

1) Onicon Corp.

2) Equal

**O. CO2 Sensors/Transmitters (CO2)**

1. **CO2-1: Wall mounted.**
   
   a. Non-dispersive infrared sensor with dual beam or dual wavelength technology where a reference channel is used to maintain sensor calibration. Single beam sensors not acceptable.

   b. Detachable base with all field wiring terminations on base.

   c. Accuracy: ±60 ppm or 5% of reading from 0 to 1500 ppm at temperatures from 60°F to 90°F.

   d. Factory calibrated and set to 0-2000 ppm range (equals 4-20 mA or 0-10 V).

   e. Include elevation adjustment.

   f. The sensor shall include auto-calibration to compensate for the aging of the infrared source and shall not require recalibration for a minimum of 5 years, guaranteed. If sensor is found to be out of calibration, supplier shall recalibrate at no additional cost to the Owner within 5 years of purchase date.

   g. LCD display.

   h. Manufacturers

   1) AirTest EE80-2CT

   2) Vaisala GMW21

   3) Or equal

2. **CO2-2: Same as CO2-1 except duct mounted**

**P. BTU Meters**

1. BTU meters shall be Onicon System 10, or equal.

2. **Electronics Enclosure:**

   a. Standard: Steel NEMA 13, wall mount, 8"x10"x4"

   b. NEMA 4 (for outdoor applications)
c. Alphanumeric LCD displays total energy, total flow, energy rate, flow rate, supply temperature and return temperature. Alpha: 16 character, 0.2" high; Numeric: 6 digit, 0.4" high.

d. Isolated solid state dry contact for energy total. Contact rating: 100 mA, 50V. Contact duration: 0.5, 1, 2, or 6 sec.

e. Analog Output(s) (4-20 mA, 0-10 V or 0-5 V):

f. Serial Communications: BACnet MS/TP, coordinate with BAS system.

3. Temperature Thermowells:

   a. Hot tap stainless steel thermowells with isolation valves.

   b. Use Onicon Solid state temperature sensors custom calibrated using N.I.S.T. traceable temperature standards. Current based signal (mA) is unaffected by wire length.

Q. Flow Sensors:


R. Occupancy Sensor:

   1. Dual Sensing ceiling mounted occupancy sensor with passive infrared and ultrasonic sensors, with output contact for Mechanical system Interface, red and green LED indicators, and 5 seconds to 30 minutes “OFF” time delay.

2.10 CALIBRATION AND TESTING INSTRUMENTATION

A. Provide instrumentation required to verify readings, calibrate sensors, and test the system and equipment performance.

B. All equipment used for testing and calibration shall be NIST/NBS traceable and calibrated within the preceding 6-month period. Certificates of calibration shall be submitted.

C. Test equipment used for testing and calibration of field devices shall be at least twice as accurate as respective field device (for example if field device is ±0.5% accurate, test equipment shall be ±0.25% accurate over same range).

2.11 CONTROL POINTS

A. Control points shown are typical. Adjust and modify the control points to suit the system configurations. Provide control points list for each system.

B. Table Column Definitions

   1. Point description
2. Type (number in point schedule after each type refers to tag on schematics)
   a. AO: analog output
   b. AI: analog input
   c. DO: digital or binary output
   d. DI: digital or binary input

3. Device description
   a. See Paragraph 2.6 for device definition.

4. Trend Logging
   a. Commissioning: Where listed, point is to be trended at the basis listed for commissioning and performance verification purposes.
   b. Continuous: Where listed, point is to be trended at the basis listed continuously, initiated after system acceptance, for the purpose of future diagnostics.
   c. Trend Basis
      1) Where range of engineering units is listed, trend on a change of value (COV) basis (in other words record time stamp and value when point value changes by engineering unit listed).
      2) Where time interval is listed, trend on a time basis (in other words record time stamp and value at interval listed). All points relating to a specific piece of equipment shall be trended at the same initiation time of day so data can be compared in text format.

5. Calibration
   a. F = factory calibration only is required (no field calibration)
   b. HH = field calibrate with handheld device.
   c. DB = field calibrate with a drywell bath.

C. Note that points lists below are for each system of like kind. Refer to drawings for quantity of each.

D. Points mapped through gateways and network interfaces
   1. Variable speed drives (typical of VFD driven fans and pumps): The following points shall be mapped over from the VFD network card as a minimum for each of pump or
fan that has a variable speed drive. (Note VFD start/stop and speed are hardware points as indicated in points list below and shall not be mapped through the gateway.)

<table>
<thead>
<tr>
<th>Description</th>
<th>Type</th>
<th>Device</th>
<th>Trend Logging</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Commissioning</td>
<td>Continuous</td>
</tr>
<tr>
<td>Fault reset</td>
<td>DO</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>On/off status</td>
<td>DI</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Fault (Critical Alarm)</td>
<td>DI</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Minor Alarm</td>
<td>DI</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Fault Text</td>
<td>DI</td>
<td>Through network (convert code to plain English text)</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Alarm Text</td>
<td>DI</td>
<td>Through network (convert code to plain English text)</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Keypad in hand/auto</td>
<td>DI</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Minimum frequency setpoint</td>
<td>AO</td>
<td>Through network</td>
<td>±5%</td>
<td>±5%</td>
</tr>
<tr>
<td>Maximum frequency setpoint</td>
<td>AO</td>
<td>Through network</td>
<td>±5%</td>
<td>±5%</td>
</tr>
<tr>
<td>Acceleration rate</td>
<td>AO</td>
<td>Through network</td>
<td>±5%</td>
<td>±5%</td>
</tr>
<tr>
<td>Deceleration rate</td>
<td>AO</td>
<td>Through network</td>
<td>±5%</td>
<td>±5%</td>
</tr>
<tr>
<td>Actual frequency</td>
<td>AI</td>
<td>Through network</td>
<td>1 min</td>
<td>15 min</td>
</tr>
<tr>
<td>AC output voltage</td>
<td>AI</td>
<td>Through network</td>
<td>±10%</td>
<td>±10%</td>
</tr>
<tr>
<td>Current</td>
<td>AI</td>
<td>Through network</td>
<td>15 min</td>
<td>60 min</td>
</tr>
<tr>
<td>VFD temperature</td>
<td>AI</td>
<td>Through network</td>
<td>60 min</td>
<td>60 min</td>
</tr>
<tr>
<td>Power, kW</td>
<td>AI</td>
<td>Through network</td>
<td>1 min</td>
<td>15 min</td>
</tr>
<tr>
<td>Energy, MWh</td>
<td>AI</td>
<td>Through network</td>
<td>15 min</td>
<td>60 min</td>
</tr>
<tr>
<td>DC Bus Voltage</td>
<td>AI</td>
<td>Through network</td>
<td>±10%</td>
<td>±10%</td>
</tr>
</tbody>
</table>
2. Water cooled Chillers: The following points shall be mapped over from the chiller gateway panel as a minimum for each chiller. (Note chiller start/stop is a hardware point as indicated in points list below and shall not be mapped through the gateway.)

<table>
<thead>
<tr>
<th>Description</th>
<th>Type</th>
<th>Device</th>
<th>Trend Logging</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>Type</td>
<td>Device</td>
<td>Trend Logging</td>
<td>Calibration</td>
</tr>
<tr>
<td>On/off status</td>
<td>DI</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Alarm</td>
<td>DI or AI</td>
<td>Through network (May have multiple integer values depending on alarm type – see chiller BACnet panel)</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Call for condenser water pump</td>
<td>DI</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Condenser water flow status</td>
<td>DI</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Call for chilled water pump</td>
<td>DI</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Chilled water flow status</td>
<td>DI</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Chiller in local mode</td>
<td>DI</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Chiller in surge</td>
<td>DI</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Chilled water temperature setpoint reset</td>
<td>AO</td>
<td>Through network</td>
<td>1 min.</td>
<td>±2°F</td>
</tr>
<tr>
<td>Demand limit setpoint</td>
<td>AO</td>
<td>Through network</td>
<td>±5%</td>
<td>±5%</td>
</tr>
<tr>
<td>Total number of surge events</td>
<td>AI</td>
<td>Through network</td>
<td>+1</td>
<td>+1</td>
</tr>
<tr>
<td>Chilled water supply temperature</td>
<td>AI</td>
<td>Through network</td>
<td>1 min.</td>
<td>10 min.</td>
</tr>
<tr>
<td>Chilled water return temperature</td>
<td>AI</td>
<td>Through network</td>
<td>1 min.</td>
<td>10 min.</td>
</tr>
<tr>
<td>Condenser water supply temperature</td>
<td>AI</td>
<td>Through network</td>
<td>1 min.</td>
<td>10 min.</td>
</tr>
<tr>
<td>Condenser water return temperature</td>
<td>AI</td>
<td>Through network</td>
<td>1 min.</td>
<td>10 min.</td>
</tr>
<tr>
<td>Condenser temperature</td>
<td>AI</td>
<td>Through network</td>
<td>–</td>
<td>10 min.</td>
</tr>
<tr>
<td>Evaporator temperature</td>
<td>AI</td>
<td>Through network</td>
<td>–</td>
<td>10 min.</td>
</tr>
<tr>
<td>Condenser (head) pressure</td>
<td>AI</td>
<td>Through network</td>
<td>–</td>
<td>10 min.</td>
</tr>
<tr>
<td>Evaporator pressure</td>
<td>AI</td>
<td>Through network</td>
<td>–</td>
<td>10 min.</td>
</tr>
<tr>
<td>Anti-recycle time remaining</td>
<td>AI</td>
<td>Through network</td>
<td>–</td>
<td>10 min.</td>
</tr>
<tr>
<td>Variable speed drive speed</td>
<td>AI</td>
<td>Through network</td>
<td>1 min.</td>
<td>10 min.</td>
</tr>
<tr>
<td>Inlet guide vane signal</td>
<td>AI</td>
<td>Through network</td>
<td>1 min.</td>
<td>10 min.</td>
</tr>
<tr>
<td>Operating hours</td>
<td>AI</td>
<td>Through network</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Oil pressure</td>
<td>AI</td>
<td>Through network</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Oil sump temperature</td>
<td>AI</td>
<td>Through network</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Power, kW</td>
<td>AI</td>
<td>Through network</td>
<td>1 min.</td>
<td>10 min.</td>
</tr>
<tr>
<td>Percent of full load current (%FLA)</td>
<td>AI</td>
<td>Through network</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>
### 3. Air cooled Chillers

The following points shall be mapped over from the chiller gateway panel as a minimum for each chiller. (Note chiller start/stop is a hardware point as indicated in points list below and shall not be mapped through the gateway.)

<table>
<thead>
<tr>
<th>Description</th>
<th>Type</th>
<th>Device</th>
<th>Trend Logging</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Commissioning</td>
<td>Continuous</td>
</tr>
<tr>
<td>On/off status</td>
<td>DI</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Alarm</td>
<td>DI or AI</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Call for chilled water pump</td>
<td>DI</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Chilled water flow status</td>
<td>DI</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Chiller in local mode</td>
<td>DI</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Chilled water temperature setpoint reset</td>
<td>AO</td>
<td>Through network</td>
<td>1 min. ±2°F</td>
<td>–</td>
</tr>
<tr>
<td>Demand limit setpoint</td>
<td>AO</td>
<td>Through network</td>
<td>±5%</td>
<td>±5%</td>
</tr>
<tr>
<td>Chilled water supply temperature</td>
<td>AI</td>
<td>Through network</td>
<td>1 min. 10 min.</td>
<td>F</td>
</tr>
<tr>
<td>Chilled water return temperature</td>
<td>AI</td>
<td>Through network</td>
<td>1 min. 10 min.</td>
<td>F</td>
</tr>
<tr>
<td>Condenser temperature</td>
<td>AI</td>
<td>Through network</td>
<td>–</td>
<td>10 min. F</td>
</tr>
<tr>
<td>Evaporator temperature</td>
<td>AI</td>
<td>Through network</td>
<td>–</td>
<td>10 min. F</td>
</tr>
<tr>
<td>Condenser (head) pressure</td>
<td>AI</td>
<td>Through network</td>
<td>–</td>
<td>10 min. F</td>
</tr>
<tr>
<td>Evaporator pressure</td>
<td>AI</td>
<td>Through network</td>
<td>–</td>
<td>10 min. F</td>
</tr>
<tr>
<td>Anti-recycle time remaining</td>
<td>AI</td>
<td>Through network</td>
<td>–</td>
<td>10 min. –</td>
</tr>
<tr>
<td>Variable speed drive speed</td>
<td>AI</td>
<td>Through network</td>
<td>1 min. 10 min.</td>
<td>–</td>
</tr>
<tr>
<td>Operating hours</td>
<td>AI</td>
<td>Through network</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Oil pressure</td>
<td>AI</td>
<td>Through network</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Oil sump temperature</td>
<td>AI</td>
<td>Through network</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Power, kW</td>
<td>AI</td>
<td>Through network</td>
<td>1 min. 10 min.</td>
<td>–</td>
</tr>
<tr>
<td>Percent of full load</td>
<td>AI</td>
<td>Through network</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Chilled water differential pressure</td>
<td>AI</td>
<td>Through network</td>
<td>1 min. 10 min.</td>
<td>F</td>
</tr>
</tbody>
</table>

### 4. Boilers
### Trend Logging

<table>
<thead>
<tr>
<th>Description</th>
<th>Type</th>
<th>Device</th>
<th>Trend Logging</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Status/fault code 1-47</td>
<td>AI</td>
<td>Through network</td>
<td>±1</td>
<td>±1</td>
</tr>
<tr>
<td>Unit Status code 0-5</td>
<td>AI</td>
<td>Through network</td>
<td>±1</td>
<td>±1</td>
</tr>
<tr>
<td>HW supply temperature</td>
<td>AI</td>
<td>Through network</td>
<td>1 min. 10 min.</td>
<td>F</td>
</tr>
<tr>
<td>HW return temperature</td>
<td>AI</td>
<td>Through network</td>
<td>10 min. 10 min.</td>
<td>F</td>
</tr>
<tr>
<td>Exhaust temperature</td>
<td>AI</td>
<td>Through network</td>
<td>10 min. 10 min.</td>
<td>F</td>
</tr>
<tr>
<td>FFWD temperature</td>
<td>AI</td>
<td>Through network</td>
<td>10 min. 10 min.</td>
<td>F</td>
</tr>
<tr>
<td>Firing rate %</td>
<td>AI</td>
<td>Through network</td>
<td>1 min. 10 min.</td>
<td>F</td>
</tr>
<tr>
<td>O2 level</td>
<td>AI</td>
<td>Through network</td>
<td>10 min. 10 min.</td>
<td>F</td>
</tr>
<tr>
<td>CO level</td>
<td>AI</td>
<td>Through network</td>
<td>10 min. 10 min.</td>
<td>F</td>
</tr>
<tr>
<td>Flame strength %</td>
<td>AI</td>
<td>Through network</td>
<td>10 min. 10 min.</td>
<td>F</td>
</tr>
<tr>
<td>Active HWST setpoint</td>
<td>AI</td>
<td>Through network</td>
<td>1 min. 10 min.</td>
<td>F</td>
</tr>
<tr>
<td>HWST Setpoint command</td>
<td>AO</td>
<td>Through network</td>
<td>±1°F ±1°F</td>
<td>–</td>
</tr>
</tbody>
</table>

### 5. Packaged Roof AC Units

<table>
<thead>
<tr>
<th>Description</th>
<th>Point Access</th>
<th>Units</th>
<th>BACnet Info</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPT Sensor</td>
<td>Read Only</td>
<td>°F</td>
<td>zone_temp_zone_temp Al:1</td>
</tr>
<tr>
<td>Active Compressor Stages</td>
<td>Read Only</td>
<td>No units</td>
<td>comp_run AV:2020</td>
</tr>
<tr>
<td>Active Heat Stages</td>
<td>Read Only</td>
<td>No units</td>
<td>heat_run AV:2003</td>
</tr>
<tr>
<td>Air Source Outdoor Air Temp</td>
<td>Read Only</td>
<td>°F</td>
<td>link_ahu_oat AV:2609</td>
</tr>
<tr>
<td>Air Source Supply Air Temp</td>
<td>Read Only</td>
<td>°F</td>
<td>link_sat AV:2608</td>
</tr>
<tr>
<td>Compressor 1 Runtime</td>
<td>Read Only</td>
<td>hr</td>
<td>comp1_mtm AV:2017</td>
</tr>
<tr>
<td>Compressor 1 Service Alarm Timer</td>
<td>R/W</td>
<td>hr</td>
<td>comp1_service_hrs AV:83006</td>
</tr>
<tr>
<td>Compressor 2 Runtime</td>
<td>Read Only</td>
<td>hr</td>
<td>comp2_mtm AV:2018</td>
</tr>
<tr>
<td>Compressor 2 Service Alarm Timer</td>
<td>R/W</td>
<td>hr</td>
<td>comp2_service_hrs AV:83007</td>
</tr>
<tr>
<td>Cooling Lockout Temperature</td>
<td>R/W</td>
<td>°F</td>
<td>oat_cl_lockout AV:9002</td>
</tr>
<tr>
<td>DCV Max Ctrl Setpoint</td>
<td>R/W</td>
<td>ppm</td>
<td>iaq_stpt_max AV:3013</td>
</tr>
<tr>
<td>DCV Max Vent Damper Pos</td>
<td>R/W</td>
<td>%Open</td>
<td>iaq_dpr_max AV:9011</td>
</tr>
<tr>
<td>Economizer High OAT Lockout Temp</td>
<td>R/W</td>
<td>°F</td>
<td>oat_ec_lockout AV:9002</td>
</tr>
<tr>
<td>Economizer Output</td>
<td>Read Only</td>
<td>%Open</td>
<td>econ_output AV:2022</td>
</tr>
<tr>
<td>Economizer Purge Min Pos</td>
<td>R/W</td>
<td>%Open</td>
<td>econ_purge_min AV:9029</td>
</tr>
<tr>
<td>Economizer Test</td>
<td>R/W</td>
<td>%Open</td>
<td>econ_test AV:81001</td>
</tr>
<tr>
<td>Effective Cool Setpoint</td>
<td>Read Only</td>
<td>°F</td>
<td>eff_cl_stpt AV:3005</td>
</tr>
<tr>
<td>Effective Heat Setpoint</td>
<td>Read Only</td>
<td>°F</td>
<td>eff_ht_stpt AV:3006</td>
</tr>
<tr>
<td>Factory Test Analog 1 Control</td>
<td>R/W</td>
<td>%</td>
<td>ao1_fac_test AV:91001</td>
</tr>
<tr>
<td>Factory Test Analog 2 Control</td>
<td>R/W</td>
<td>V</td>
<td>ao2_fac_test AV:91002</td>
</tr>
<tr>
<td>Fan Off Delay</td>
<td>R/W</td>
<td>seconds</td>
<td>fan_delay_off AV:9024</td>
</tr>
<tr>
<td>Filter Runtime</td>
<td>Read Only</td>
<td>hr</td>
<td>filter_mtm AV:2015</td>
</tr>
<tr>
<td>Filter Service Alarm Timer</td>
<td>R/W</td>
<td>hr</td>
<td>filter_service_hrs AV:2019</td>
</tr>
</tbody>
</table>

05/22/2018

BUILDING AUTOMATION SYSTEM

Contra Costa Community College District
Mechanical and Controls Design-Build Project
C-1129 PAC Boiler Replacement D-1044 Campus-Wide EMS Upgrades
C-1130 PAC Chiller Replacement D-4017 Mechanical Equipment Retrofit
C-1131 AT Packaged Unit Replacement P-4022 AHU Replacement
### E. Hard-wired Points

#### 1. VAV Box with reheat

<table>
<thead>
<tr>
<th>Description</th>
<th>Type</th>
<th>Device</th>
<th>Trend Logging</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td>VAV Box Damper Position</td>
<td>AO (or two DOs and an AI)</td>
<td>Modulating (or floating with position feedback) actuator</td>
<td>1 min</td>
<td>15 min</td>
</tr>
<tr>
<td>HW valve signal</td>
<td>AO</td>
<td>2-way valve (occasional 3-way valve – see equipment schedule)</td>
<td>1 min</td>
<td></td>
</tr>
<tr>
<td>Local Override</td>
<td>DI</td>
<td>TS-3x – where applicable (see Paragraph 2.10F).</td>
<td>COV</td>
<td>COV</td>
</tr>
</tbody>
</table>
### Supply Airflow
- AI: DPT-5 connected to box manufacturer supplied flow cross, 1 min, 15 min, HH

### Supply air temperature
- AI: TS-1A, 1 min, 15 min, F

### Zone Temperature Setpoint Adjustment
- AI: TS-3x – where applicable (see Paragraph 2.10F), 15 min, 60 min, F

### Zone Temperature
- AI: TS-3x (see Paragraph 2.10F), 1 min, 15 min, F

### Zone CO2 Concentration
- AI: CO2-1 (where indicated on Drawings), 5 min, 15 min, F

## 2. Typical Air Cooled Chiller Plant

<table>
<thead>
<tr>
<th>Description</th>
<th>Type</th>
<th>Device</th>
<th>Trend Logging</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td>CH-1 on/off</td>
<td>DO</td>
<td>Connect to chiller enable contact on chiller panel</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>CH-1 Alarm</td>
<td>DI</td>
<td>Connect to general alarm dry contact</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>VFD Pump P-1 Start/Stop (where applicable)</td>
<td>DO</td>
<td>Connect to VFD</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>VFD Pump P-2 Start/Stop (where applicable)</td>
<td>DO</td>
<td>Connect to VFD</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Pump Speed (P-1)</td>
<td>AO</td>
<td>Connected to VFD Speed on drive</td>
<td>1 min, 5 min</td>
<td>–</td>
</tr>
<tr>
<td>Pump Speed (P-2)</td>
<td>AO</td>
<td>Connected to VFD Speed on drive</td>
<td>1 min, 5 min</td>
<td>–</td>
</tr>
<tr>
<td>Pump P-1 Start/Stop (where applicable)</td>
<td>DO</td>
<td>Motor Starter</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Pump P-2 Start/Stop (where applicable)</td>
<td>DO</td>
<td>Motor Starter</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>CH1 Supply temperature reset</td>
<td>AO</td>
<td>Chiller control panel</td>
<td>5 min, 15 min</td>
<td>–</td>
</tr>
<tr>
<td>CH1 Supply temperature</td>
<td>AI</td>
<td>TS</td>
<td>5 min, 15 min</td>
<td>DB</td>
</tr>
<tr>
<td>CHW differential pressure</td>
<td>AI</td>
<td>DPT, 0 to 20 psi</td>
<td>5 min, 15 min</td>
<td>F</td>
</tr>
<tr>
<td>CHWR temperature</td>
<td>AI</td>
<td>TS</td>
<td>5 min, 15 min</td>
<td>DB</td>
</tr>
<tr>
<td>CHWS temperature</td>
<td>AI</td>
<td>TS</td>
<td>5 min, 15 min</td>
<td>DB</td>
</tr>
<tr>
<td>CHW Flow</td>
<td>AI</td>
<td>FM</td>
<td>5 min, 15 min</td>
<td>–</td>
</tr>
</tbody>
</table>
### Boilers

<table>
<thead>
<tr>
<th>Description</th>
<th>Type</th>
<th>Device</th>
<th>Trend Logging</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td>HWP1 Start</td>
<td>DO</td>
<td>Wire to (E) pump starter</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>HWST common</td>
<td>AI</td>
<td>Wire to (E) temperature sensor</td>
<td>1 min.</td>
<td>10 min.</td>
</tr>
<tr>
<td>HWRT common</td>
<td>AI</td>
<td>Wire to (E) temperature sensor</td>
<td>10 min.</td>
<td>10 min.</td>
</tr>
<tr>
<td>HWP Status</td>
<td>DI</td>
<td>Wire to Current Sensor</td>
<td>COV</td>
<td>COV</td>
</tr>
</tbody>
</table>

### VAV Air Handler

<table>
<thead>
<tr>
<th>Description</th>
<th>Type</th>
<th>Device</th>
<th>Trend Logging</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relief damper open/close</td>
<td>AO</td>
<td>Modulating actuator</td>
<td>1 min</td>
<td>15 min</td>
</tr>
<tr>
<td>Outdoor air/Return air damper open/close</td>
<td>AO</td>
<td>Modulating actuator</td>
<td>1 min</td>
<td>15 min</td>
</tr>
<tr>
<td>Relief Fan Start/Stop</td>
<td>DO</td>
<td>Connect to VFD Run</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Supply1 Fan Start/Stop (via Fan ISO damper endswitch)</td>
<td>DO</td>
<td>Connect to Fan Iso Damper Actuator</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Supply2 Fan Start/Stop (via Fan ISO damper endswitch)</td>
<td>DO</td>
<td>Connect to Fan Iso Damper Actuator</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Relief Fan Speed</td>
<td>AO</td>
<td>Connect to VFD Speed</td>
<td>1 min</td>
<td>15 min</td>
</tr>
<tr>
<td>Supply Fan1 Speed</td>
<td>AO</td>
<td>Connect to VFD Speed</td>
<td>1 min</td>
<td>15 min</td>
</tr>
<tr>
<td>Return Fan Speed</td>
<td>AO</td>
<td>Connect to VFD Speed</td>
<td>1 min</td>
<td>15 min</td>
</tr>
<tr>
<td>Relief Fan Status</td>
<td>DI</td>
<td>Connect to VFD</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Supply Fan Status</td>
<td>DI</td>
<td>Connect to VFD</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Return Fan Status</td>
<td>DI</td>
<td>Connect to VFD</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Supply fan high static alarm reset</td>
<td>DO</td>
<td>Dry contact to 120V or 24V control circuit –see control sequences for details</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Chilled Water Control Valve</td>
<td>AO</td>
<td>Modulating 2-way valve</td>
<td>1 min</td>
<td>15 min</td>
</tr>
<tr>
<td>Mixed Air Temperature</td>
<td>AI</td>
<td>TS across filter bank</td>
<td>1 min</td>
<td>15 min</td>
</tr>
<tr>
<td>Filter Pressure Drop</td>
<td>AI</td>
<td>DPT, 0 to 1 inch</td>
<td>–</td>
<td>60 min</td>
</tr>
<tr>
<td>Return Air Temperature</td>
<td>AI</td>
<td>TS</td>
<td>1 min</td>
<td>15 min</td>
</tr>
<tr>
<td>Supply Air Temperature</td>
<td>AI</td>
<td>TS</td>
<td>1 min</td>
<td>15 min</td>
</tr>
<tr>
<td>Duct Static Pressure</td>
<td>AI</td>
<td>DPT, 0 to 2 inches</td>
<td>1 min</td>
<td>15 min</td>
</tr>
</tbody>
</table>
### 5. Chiller / Tower Plant

<table>
<thead>
<tr>
<th>Description</th>
<th>Type</th>
<th>Device</th>
<th>Trend Logging</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td>CH-1 on/off</td>
<td>DO</td>
<td>Connected to chiller enable contact on chiller panel</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>CH-1 Alarm</td>
<td>DI</td>
<td>Connected to general alarm dry contact</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>CHWP (P-1) Start/Stop</td>
<td>DO</td>
<td>Connected to VFD</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>CHWP (P-2) Start/Stop</td>
<td>DO</td>
<td>Connected to VFD</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>CWP-1 Start/Stop</td>
<td>DO</td>
<td>Connected to VFD</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>CWP-2 Start/Stop</td>
<td>DO</td>
<td>Connected to VFD</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>CHWP (P-1) Status</td>
<td>DI</td>
<td>Connected to VFD</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>CHWP (P-2) Status</td>
<td>DI</td>
<td>Connected to VFD</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>CWP-1 Status</td>
<td>DI</td>
<td>Connected to VFD</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>CWP-2 Status</td>
<td>DI</td>
<td>Connected to VFD</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>CHWP (P-1) Speed</td>
<td>AO</td>
<td>Connected to VFD Speed on drive</td>
<td>1 min 5 min</td>
<td>--</td>
</tr>
<tr>
<td>CHWP (P-2) Speed</td>
<td>AO</td>
<td>Connected to VFD Speed on drive</td>
<td>1 min 5 min</td>
<td>--</td>
</tr>
<tr>
<td>CWP-1 Speed</td>
<td>AO</td>
<td>Connected to VFD</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>CWP-2 Speed</td>
<td>AO</td>
<td>Connected to VFD</td>
<td>COV</td>
<td>COV</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Description</th>
<th>Type</th>
<th>Device</th>
<th>Trend Logging</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT cell 1 fan S/S</td>
<td>DO</td>
<td>Currently connected to starter, connect to new VFD</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>CT cell 1 fan Status</td>
<td>DI</td>
<td>Currently connected to starter, connect to new VFD</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>CT-1 speed</td>
<td>AO</td>
<td>Connect to VFD Speed on CT</td>
<td>1 min 5 min</td>
<td>--</td>
</tr>
<tr>
<td>CWS Bypass valve</td>
<td>AO</td>
<td>Modulating butterfly valve</td>
<td>1 min 5 min</td>
<td>--</td>
</tr>
<tr>
<td>CWS temperature from tower</td>
<td>AI</td>
<td>TS</td>
<td>5 min 15 min</td>
<td>HH</td>
</tr>
<tr>
<td>CWS temperature from towers CT-1</td>
<td>AI</td>
<td>TS</td>
<td>5 min 15 min</td>
<td>HH</td>
</tr>
<tr>
<td>CWR temperature from towers CT-1</td>
<td>AI</td>
<td>TS</td>
<td>5 min 15 min</td>
<td>HH</td>
</tr>
<tr>
<td>CH1 Supply temperature reset</td>
<td>AO</td>
<td>Chiller control panel</td>
<td>5 min 15 min</td>
<td>--</td>
</tr>
</tbody>
</table>
6. Miscellaneous Points
   a. New sensors shown in white, greyed out sensors already exist but need to be rewired.

<table>
<thead>
<tr>
<th>Description</th>
<th>Type</th>
<th>Device</th>
<th>Trend Logging</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outdoor Air Temperature</td>
<td>Al</td>
<td>TS, located on North face</td>
<td>1 min, 15 min</td>
<td>HH</td>
</tr>
<tr>
<td>Building Pressure</td>
<td>Al</td>
<td>DPT, ±0.25</td>
<td>1 min, 15 min</td>
<td>F</td>
</tr>
<tr>
<td>Outdoor Air Relative Humidity</td>
<td>H</td>
<td></td>
<td>1 min, 15 min</td>
<td>HH</td>
</tr>
</tbody>
</table>

PART 3 - EXECUTION

3.01 GENERAL
   A. The Owner will provide the permanent IP connection to the network controller the GUI, as long as they have been identified during the submittal phase.
   B. The BAS Design Builder shall provide any temporary network wiring required during the startup, checkout and commissioning phase for testing of the system.
   C. From the time of system startup thru the commissioning phase to the end of construction, the Design Builder shall provide a broadband internet connection to the system that will allow the Design Builder and Owner representatives to access the system from any location on and off site. This connection shall be maintained by the Design Builder and not depend on the Owners network. The Design Builder shall be responsible for the installation and maintenance of this temporary connection to the ISP at least until the systems is accepted or permanently connected to the Owners Graphic User Interface.

3.02 DELIVERY, STORAGE AND HANDLING
   A. Provide factory-shipping cartons for each piece of equipment and control device. Maintain cartons during shipping, storage and handling as required to prevent equipment damage, and to eliminate dirt and moisture from equipment.
B. Store equipment and materials inside and protect from weather.

3.03 IDENTIFICATION

A. General

1. Manufacturers’ nameplates and UL or CSA labels to be visible and legible after equipment is installed.

2. Identifiers shall match record documents.

3. All plug-in components shall be labeled such that removal of the component does not remove the label.

B. Wiring

1. All wiring and cabling, including that within factory-fabricated panels, shall be labeled at each end within 2 inches of termination with the BAS address or termination number.

2. Permanently label or code each point of field terminal strips to show the instrument or item served.

C. Equipment and Devices

1. Valve and damper actuators: None required.

2. Sensors: Provide 1 inch x 3 inches x 1/8 inches black micarta or lamacoid labels with engraved white lettering, ¼ inches high. Indicate sensor identifier and function (for example “CHWS Temp”).

3. Panels

   a. Provide 2 inches x 5 inches 1/8 inches black micarta or lamacoid labels with engraved white lettering, ½ inches high. Indicate panel identifier and service.

   b. Provide permanent tag indicating the electrical panel and circuit number from which panel is powered.

4. Identify room sensors relating to terminal box or valves with indelible marker on sensor hidden by cover.

3.04 CUTTING, CORING, PATCHING AND PAINTING

A. Provide canning for openings in concrete walls and floors and other structural elements prior to their construction.

B. Penetrations through rated walls or floors shall be filled with a listed material to provide a code compliant fire-stop.
C. All damage to and openings in ductwork, piping insulation, and other materials and equipment resulting from Work in this Section shall be properly sealed, repaired, or re-insulated by experienced mechanics of the trade involved. Repair insulation to maintain integrity of insulation and vapor barrier jacket. Use hydraulic insulating cement to fill voids and finish with material matching or compatible with adjacent jacket material.

D. At the completion of Work, all equipment furnished under this Section shall be checked for paint damage, and any factory-finished paint that has been damaged shall be repaired and repainted to original finish.

3.05 CLEANING

A. Clean up all debris resulting from its activities daily. Remove all cartons, containers, crates, and other debris generated by Work in this Section as soon as their contents have been removed. Waste shall be collected and legally disposed of.

B. Materials stored on-site shall be protected from weather and stored in an orderly manner, neatly stacked, or piled in the designated area assigned by the Owner's Representative.

C. At the completion of work in any area, clean all work and equipment of dust, dirt, and debris.

D. Use only cleaning materials recommended by the manufacturer of the surfaces to be cleaned and on surfaces recommended by the cleaning material manufacturer.

3.06 CONTROLLERS

A. General

1. Install systems and materials in accordance with manufacturer’s instructions, specifications roughing-in drawings and details indicated on Drawings.

2. Regardless of application category listed below, each Control Unit shall be capable of performing the specified sequence of operation for the associated equipment. Except as listed below, all physical point data and calculated values required to accomplish the sequence of operation shall reside within the associated CU. Refer to Paragraph 2.3B above for physical limitations of standalone functionality. Listed below are point data and calculated values that shall be allowed to be obtained from other CUs via LAN.

   a. Global points such as outdoor air temperature

   b. Requests, such as heat/cool requests, used to request operation or for setpoint reset from zones to systems and systems to plants.

   c. Modes, such as system modes, used to change operating logic from plants to systems and systems to zones.

3. Where associated control functions involve functions from different categories identified below, the requirements for the most restrictive category shall be met.
B. Controller Application Categories

1. Controllers shall comply with the application table below (X under controller type indicates acceptable controller type).

<table>
<thead>
<tr>
<th>Application Category</th>
<th>Examples</th>
<th>Acceptable Controller</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Monitoring of variables that are not used in a control loop, sequence logic, or safety, such as status of sump pumps or associated float switches, temperatures in monitored electrical rooms.</td>
<td>ASC: yes, AAC: yes, BC: yes</td>
</tr>
</tbody>
</table>
| 1                    | • Fan Coil Units  
• Terminal Units (such as VAV Boxes)  
• Miscellaneous heaters  
• Constant speed exhaust fans and pumps  
• Packaged units with self contained controls | ASC: yes, AAC: yes, BC: yes |
| 2                    | • Air Handling Units  
• Central Hot Water Plant | ASC: yes, AAC: note 1, BC: yes |
| 3                    | • Central Chilled Water Plant | ASC: no, AAC: no, BC: yes |

Notes:
1. AAC may be used only if all control functions and physical I/O associated with a given unit resides in one AAC

2. ASC Installation
   a. ASCs that control equipment located above accessible ceilings shall be mounted on the equipment in an accessible enclosure and shall be rated for plenum use if ceiling attic is used as a return air plenum.
   b. ASCs that control equipment mounted in a mechanical room may either be mounted in or on the equipment, or on the wall of the mechanical room at an adjacent, accessible location.
   c. ASCs that control equipment mounted outside or in occupied spaces shall either be located in the unit or in a proximate mechanical/utility space.
   d. Furnish ASCs to the VAV terminal unit manufacturer for factory mounting.

3. AAC and BC Installation
a. AACs/BCs that control equipment located above accessible ceilings shall be mounted in a NEMA 1, locking enclosure and shall be rated for plenum use if ceiling attic is used as a return air plenum.

b. AACs/BCs that control equipment located in occupied spaces or outside shall either be mounted within the equipment enclosure (responsibility for physical fit remains with the Design Builder) or in a proximate mechanical/utility room in which case it shall be enclosed in a NEMA 1, locking enclosure.

4. Application Category 0 (Distributed Monitoring)

a. Applications in this category include monitoring of variables that are not used in a control loop, sequence logic, or safety. Examples include status of sump pumps or associated float switches, temperatures in monitored electrical rooms.

b. Applicable Controllers: Available points on conveniently located BCs, AACs, and ASCs may be used in these applications.

c. Verify and document that the network bandwidth is acceptable to accept specified trends of monitored points.

5. Application Category 1 (Application Specific Controller)

a. Applications in this category include the following:

1) Fan Coil Units

2) Terminal Units (such as VAV and Constant Volume Boxes)

3) Miscellaneous heaters

4) Constant speed exhaust fans and pumps

5) Unitary single zone units with self contained controls (Package Terminal AC Units, Package Terminal Heat Pumps, Split-System AC Units, Split-System Heat Pumps, Water-Source Heat Pumps, Computer Room AC units)

b. Applicable Controllers: ASCs may be used in these applications

c. Standalone Capability: Provide capability to execute control functions for the application for a given setpoint or mode, which shall generally be occupied mode control. Only the following data (as applicable) may be acquired from other controllers via LANs. In the event of a loss of communications with any other controller, or any fault in any system hardware that interrupts the acquisition of any of these values, the ASC shall use the last value obtained before the fault occurred. If such fault has not been corrected after the
specified default delay time, specified default value(s) shall then be substituted until such fault has been corrected.

<table>
<thead>
<tr>
<th>Physical/Virtual Point</th>
<th>Default Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time of day</td>
<td>Occupied</td>
</tr>
<tr>
<td>Scheduling Mode</td>
<td>Occupied</td>
</tr>
<tr>
<td>Morning Warm-Up</td>
<td>Off (cold discharge air)</td>
</tr>
<tr>
<td>Load Shed</td>
<td>Off (no shedding)</td>
</tr>
<tr>
<td>Trend Data</td>
<td>N/A</td>
</tr>
</tbody>
</table>

d. Mounting

1) ASCs that control equipment located above accessible ceilings shall be mounted on the equipment in an accessible enclosure and shall be rated for plenum use if ceiling attic is used as a return air plenum.

2) ASCs that control equipment mounted in a mechanical room may either be mounted in or on the equipment, or on the wall of the mechanical room at an adjacent, accessible location.

3) ASCs that control equipment mounted outside or in occupied spaces shall either be located in the unit or in a proximate mechanical/utility space.

4) Furnish ASCs to the VAV terminal unit manufacturer for factory mounting.

e. LAN Restrictions: Limit the number of nodes on the network to the maximum recommended by the manufacturer.

6. Application Category 2 (Advanced Application Controller)

a. Applications in this category include the following:

1) Single Zone Air Handlers

2) Large VAV Air Handlers, provided all real control points and all control logic reside on a single AAC

b. Applicable Controllers

1) BCs may be used in these applications.

2) AACs may be used in these applications provided the AAC meets all requirements specified below and all control functions and physical I/O associated with a given unit resides in one AAC.

c. Standalone Capability: Only the following data (as applicable) may be acquired from other AACs or BCs via LANs. In the event of a loss of...
communications with any other AACS, or any fault in any system hardware that interrupts the acquisition of any of these values, the AAC shall use the last value obtained before the fault occurred. If such fault has not been corrected after the specified default delay time, specified default value(s) shall then be substituted until such fault has been corrected.

<table>
<thead>
<tr>
<th>Physical/Virtual Point</th>
<th>Default Delay Time</th>
<th>Default Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outside Air Temperature</td>
<td>3 minutes</td>
<td>80°F</td>
</tr>
<tr>
<td>Trend Data</td>
<td></td>
<td>N/A</td>
</tr>
</tbody>
</table>

d. Mounting

1) AACS/BCs that control equipment located above accessible ceilings shall be mounted in a NEMA 1, locking enclosure and shall be rated for plenum use if ceiling attic is used as a return air plenum.

2) AACS/BCs that control equipment located in occupied spaces or outside shall either be mounted within the equipment enclosure (responsibility for physical fit remains with the Design Builder) or in a proximate mechanical/utility room in which case it shall be enclosed in a NEMA 1, locking enclosure.

7. Application Category 3 (Building Controller)

a. Applications in this category include the following:

1) Large Air Handlers
2) Central Chilled Water Plant
3) Central Hot Water Plant

b. Applicable Controllers: BCs shall be used in these applications

c. Mounting: See Paragraph 3.6B.6.e.

3.07 COMMUNICATION DEVICES

A. General

1. Install systems and materials in accordance with manufacturer’s instructions, roughing-in drawings and details indicated on Drawings.

2. Provide all interface devices and software to provide an integrated system.

B. LANID and LAN Routers

1. Provide as required
2. Connect networks to both sides of device

3. Thoroughly test to ensure proper operation

4. Interruptions or fault at any point on any Primary Controller LAN shall not interrupt communications between other nodes on the network. If a LAN is severed, two separate networks shall be formed and communications within each network shall continue uninterrupted. The system shall automatically monitor the operation of all network devices and annunciate any device that goes off-line because it is failing to communicate.

C. Gateways

1. General
   a. Wire to networks on both sides of device.
   b. Map across all monitoring and control points listed in Paragraph 2.12.
   c. Thoroughly test each point to ensure that mapping is accurate.
   d. Initiate trends of points as indication in Paragraph 2.12.

2. Chiller Controls Gateway
   a. Install chiller BACnet gateway supplied with chiller(s), including mounting and wiring.
   b. Wire to each chiller panel to the gateway per manufacturer's instructions.
   c. Connect gateway to Supervisory LAN.

3. Boiler Gateway
   a. Install gateway supplied with boiler(s) in local EMCS panel or in separate NEMA 1 enclosure in boiler room.
   b. Connect gateway to Primary or Secondary LAN.

4. Variable Speed Drive Router
   a. Install router(s) in local EMCS panel or in separate NEMA 1 enclosure in mechanical or electrical room.
   b. Wire each variable speed drive network card to the router per manufacturer's instructions.
   c. Connect router to Primary or Secondary LAN.
5. VAV Air Conditioning Unit Gateway
   a. Connect each AC unit gateway to Supervisory LAN.

6. Electrical System Monitoring Gateway
   a. Install gateway(s) in local EMCS panel or in separate NEMA 1 enclosure in electrical room.

3.08 CONTROL POWER

A. Power wiring and wiring connections required for Work in this Section shall be provided under this Section unless specifically indicated on Division 26 Drawings or Specifications.

B. Extend power to all EMCS devices, including 120V power to panels, from an acceptable power panel.
   1. See Division 26 Electrical Drawings for power locations pre-allocated for EMCS system.
   2. Where no power source is indicated on drawings, for bid purposes only, assume a dedicated circuit is available within an average of 20 feet of panel location. If this is not the case, request additional cost prior to submission of shop drawings or no additional costs will be reimbursed.
   3. Coordinate with Division 26 during shop drawing development for final connection location.

C. General requirements for obtaining power include the following:
   1. Electrical service to controls panels and control devices shall be provided by isolated circuits, with no other loads attached to the circuit, clearly marked at its source. The location of the breaker shall be clearly identified in each panel served by it.
   2. Obtain power from a source that feeds the equipment being controlled such that both the control component and the equipment are powered from the same panel. Where equipment is powered from a 460V source, obtain power from the electrically most proximate 120V source fed from a common origin.
   3. Where control equipment is located inside a new equipment enclosure, coordinate with the equipment manufacturer and feed the control with the same source as the equipment. If the equipment’s control transformer is large enough and of the correct voltage to supply the controls, it may be used. If the equipment’s control transformer is not large enough or not of the correct voltage to supply the controls, provide separate transformer(s).
   4. Where a controller controls multiple systems on varying levels of power reliability (normal, emergency, or interruptible), the controller shall be powered by the highest level of reliability served.
5. Standalone Functionality: Refer to Paragraph 2.3B.

D. Unless transformers are provided with equipment as specified in related Division 23 and 26 equipment Sections, Design Builder shall provide transformers for all low voltage control devices including non-powered terminal units such as cooling-only VAV boxes and VAV boxes with hot water reheat. Transformer(s) shall be located in control panels in readily accessible locations such as Electrical Rooms.

E. Power line filtering. Provide transient voltage and surge suppression for all workstations and BCs either internally or as an external component.

3.09 CONTROL AND COMMUNICATION WIRING

A. Control and Signal Wiring


2. All NEC Class 1 (line voltage) wiring shall be UL Listed in approved raceway per NEC requirements and shall be installed by a licensed electrician.

3. All low-voltage wiring shall meet NEC Class 2 requirements. (Low-voltage power circuits shall be sub-fused when required to meet Class 2 current-limit.) Class 2 wiring shall be installed in UL Listed approved raceway, except where wires are in concealed accessible locations, approved cables not in raceway may be used, provided that cables are UL Listed for the intended application. For example, cables used in ceiling return plenums shall be UL Listed specifically for that purpose.

4. Do not install Class 2 wiring in raceway containing Class 1 wiring. Boxes and panels containing high-voltage wiring and equipment may not be used for low-voltage wiring except for the purpose of interfacing the two (for example relays and transformers).

5. Do not install Class 1 wiring in raceway containing tubing.

6. Where Class 2 wiring is used without raceway, it shall be supported from or anchored to structural members neatly tied at 10 foot intervals and at least 1 foot above ceiling tiles and light fixtures. Support or anchoring from straps or rods that support ductwork or piping is also acceptable. Cables shall not be supported by or anchored to ductwork, electrical raceways, piping, or ceilings.

7. All wire-to-device connections shall be made at a terminal block or terminal strip. All wire-to-wire connections shall be at a terminal block.

8. All field wiring shall be properly labeled at each end, with self-laminating typed labels indicating device address, for easy reference to the identification schematic. All power wiring shall be neatly labeled to indicate service, voltage, and breaker source.

9. Use coded conductors throughout with different colored conductors.
10. All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.

11. Maximum allowable voltage for control wiring shall be 120 V. If only higher voltages are available, the Design Builder shall provide step-down transformers.

12. All wiring shall be installed as continuous lengths, with no splices permitted between termination points.

13. Install plenum wiring in sleeves where it passes through walls and floors. Maintain fire rating at all penetrations.

14. Size of raceway and size and type of wire shall be the responsibility of the Design Builder, in keeping with the manufacturer's recommendation and NEC requirements.

15. Include one pull string in each raceway 1 inch or larger.

16. Control and status relays are to be located in designated enclosures only. These enclosures include packaged equipment control panel enclosures unless they also contain Class 1 starters.

17. Conceal all raceways, except within mechanical, electrical, or service rooms. Install raceway to maintain a minimum clearance of 6 inches from high-temperature equipment (for example steam pipes or flues).

18. Secure raceways with raceway clamps fastened to the structure and spaced according to code requirements. Raceways and pull boxes may not be hung on flexible duct strap or tie rods. Raceways may not be run on or attached to ductwork.

19. Install insulated bushings on all raceway ends and openings to enclosures. Seal top end of all vertical raceways.

20. Terminate all control or interlock wiring.

21. Maintain updated as-built wiring diagrams with terminations identified at the jobsite.

22. Flexible metal raceways and liquid-tight, flexible metal raceways shall not exceed 3 feet in length and shall be supported at each end. Flexible metal raceway less than ½ inches electrical trade size shall not be used. In areas exposed to moisture liquid-tight, flexible metal raceways shall be used.

23. Raceway must be rigidly installed, adequately supported, properly reamed at both ends, and left clean and free of obstructions. Raceway sections shall be joined with couplings per code. Terminations must be made with fittings at boxes and ends not terminating in boxes shall have bushings installed.

24. Wire digital outputs to either the normally-closed or normally-open contacts of binary output depending on desired action in case of system failure. Unless otherwise
indicated herein, wire to the NO contact except the following shall be wired to the NC contact

a. Hot water pumps
b. Coil recirculation pumps provided for freeze protection.

25. Hardwire Interlocks

a. The devices referenced in this Section are hardwire interlocked to ensure equipment shutdown occurs even if control systems are down. Do not use software (alone) for these interlocks.

b. Hardwire device NC contact to air handler fan starter upstream of HOA switch, or to VFD enable contact.

c. Where multiple fans (or EMCS DI) are controlled off of one device and the device does not have sufficient contacts, provide a relay at the device to provide the required number of contacts.

d. Provide for the following devices where indicated on Drawings or in Sequences of Operation:

   1) Duct smoke detector
   2) High discharge static pressure
   3) Low mixing plenum pressure
   4) Freeze-stats
   5) Cooling tower vibration switch

26. Shielded cable shield shall be grounded only at one end. Signal wiring shield shall be grounded at controller end only unless otherwise recommended by the controller manufacturer.

B. Communication Wiring

1. Adhere to the requirements of Paragraph 3.12A in addition to this Paragraph.

2. Communication and signal wiring may be run without conduit in concealed, accessible locations as permitted by Paragraph 3.12A only if noise immunity is ensured. Design Builder is fully responsible for noise immunity and rewire in conduit if electrical or RF noise affects performance.

3. All cabling shall be installed in a neat and workmanlike manner. Follow all manufacturers' installation recommendations for all communication cabling.
4. Do not install communication wiring in raceway and enclosures containing Class 1 or other Class 2 wiring.

5. Maximum pulling, tension, and bend radius for cable installation as specified by the cable manufacturer shall not be exceeded during installation.

6. Verify the integrity of the entire network following the cable installation. Use appropriate test measures for each particular cable.

7. All runs of communication wiring shall be unspliced length when that length is commercially available.

8. All communication wiring shall be labeled to indicate origination and destination data.

9. Grounding of coaxial cable shall be in accordance with NEC regulations Article on Communications Circuits, Cable and Protector Grounding.

10. Power-line carrier signal communication or transmission is not acceptable.

3.10 SENSORS AND MISCELLANEOUS FIELD DEVICES

A. Install sensors in accordance with the manufacturer’s recommendations.

B. Mount sensors rigidly and adequately for the environment within which the sensor operates.

C. Sensors used as controlled points in control loops shall be hardwired to the controller to which the controlled device is wired and in which the control loop shall reside.

D. Temperature Sensors

1. Room temperature sensors and thermostats shall be installed on concealed junction boxes properly supported by the wall framing.

   a. For sensors mounted in exterior walls or columns, seal all junction box openings with mastic sealant and pack junction box with fiberglass insulation.

   b. For sensors on exposed columns, use Wiremold or equal enclosures that are the smallest required to enclose wiring (e.g. Wiremold 400 BAC or equal) and Wiremold or equal junction boxes that are the narrowest required to enclose the temperature sensor and wiring connections (e.g. Wiremold 2348S/51 or equal). Color or raceway and boxes shall be per the architect; submit for approval prior to installation.

2. All wires attached to sensors shall be air sealed in their raceways or in the wall to stop air transmitted from other areas affecting sensor readings.

3. Averaging sensors shall be installed in a serpentine manner vertically across duct. Each bend shall be supported with a capillary clip. Where located in front of filters (such as mixed air sensors), access for filter removal shall be maintained.
4. For sensors specified to be calibrated using a dry well bath (see points list), install sensors with a sufficient wiring/flexible conduit lead that sensor may remove from well or duct and placed in an ice bath or dry well for calibration. The spare wiring/flexible conduit shall be no less than 3 feet in length.

5. All pipe-mounted temperature sensors shall be installed in wells. For small piping, well shall be installed in an elbow into pipe length. Install the sensor in the well with a thermal-conducting grease or mastic. Use a closed-cell insulation patch that is integrated into the pipe insulation system to isolate the top of the well from ambient conditions but allow easy access to the sensor. Install a test plug adjacent to all wells for testing and calibration.

6. Unless otherwise noted on Drawings or Points List, temperature sensors/thermostats, humidity sensors/humidistats, CO₂ sensors, and other room wall mounted sensors shall be installed at same centerline elevation as adjacent electrical switches, 4 feet above the finished floor where there are no adjacent electrical switches, and within ADA limitations.

7. Unless otherwise noted on Drawings or Points List, install outdoor air temperature sensors on north wall where they will not be influenced by building exhaust, exfiltration, or solar insolation. Do not install near intake or exhaust air louvers.

E. Differential Pressure Sensors

1. Supply Duct Static Pressure: Mount transmitter in temperature control panel near or in EMCS panel to which it is wired. Connect the low-pressure port to tee in building pressure (high) signal of the building static pressure transmitter. Pipe the high-pressure tap to the duct using a static pressure tip. Locate static pressure tip as indicated on Drawings; if no location is indicated, locate at end of duct riser or main as far out in the system as possible but upstream of all smoke and fire dampers. Install pressure tips securely fastened with tip facing upstream in accordance with manufacturer’s installation instructions.

2. Building Static Pressure

   a. Mount transmitter in temperature control panel near or in EMCS panel to which it is wired.

   b. Low pressure port of the pressure sensor

      1) Pipe to the ambient static pressure probe located on the outside and at high point of the building through a high-volume accumulator or otherwise protected from wind fluctuations.

   c. High-pressure port of the pressure sensor

      1) Pipe to either

         a) Behind a EMCS temperature sensor cover in an interior zone (provided sensor has openings to allow
ambient air to freely flow through it)

b) Wall plate sensor

2) Do not locate near elevators, exterior doors, atria, or (for ceiling sensor applications) near diffusers.

3. Filter Differential Pressure
   a. Install static-pressure tips upstream and downstream of filters with tips oriented in direction of flow.
   b. Mount transmitter on outside of filter housing or filter plenum in an accessible position with LCD display clearly visible. This sensor is used in lieu of an analog gauge and thus must be readily viewable.

4. Minimum Outdoor Air Damper Differential Pressure
   a. Install plenum static-pressure sensors upstream and downstream of minimum outdoor air damper in a location where air velocity is minimal.
   b. Mount transmitter on inside or outside of economizer plenum (whichever is most accessible while out of weather) in an accessible position with LCD display clearly visible.

F. Relative Humidity Sensors: Provide element guard as recommended by manufacturer for high velocity installations. For high limit sensors, position remote enough to allow full moisture absorption into the air stream before reaching the sensor.

G. Flow Switches: Install per manufacturer's instructions.

H. Current Switches for Motor Status Monitoring: Adjust so that setpoint is below minimum operating current and above motor no load current. For fans with motorized discharge dampers, adjust so that fan indicates off if damper is closed while fan is running.

I. Airflow Measuring Stations: Install per manufacturer's recommendations for unobstructed straight length of duct both upstream and downstream of sensor, except those installations specifically designed for installation in fan inlet. For installations in fan inlets, provide on both inlets of double inlet fans and provide inlet cone adapter as recommended by AFMS manufacturer.

J. Fluid Flow Meters: Install per manufacturer's recommendations for unobstructed straight length of pipe both upstream and downstream of sensor. Commission per the manufacturer's startup and commissioning recommendations. Complete all manufacturer's startup documentation and include this in pre-functional commissioning report.

K. Actuators
   1. Type: All actuators shall be electric.
2. Mount and link control damper actuators per manufacturer’s instructions.

3. Dampers
   a. To compress seals when spring-return actuators are used on normally closed dampers, power actuator to approximately 5° open position, manually close the damper, and then tighten the linkage, or follow manufacturers instructions to achieve same effect.
   b. Check operation of damper-actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed positions.
   c. Provide all mounting hardware and linkages for actuator installation.

4. Control Valves: Install so that actuators, wiring, and tubing connections are accessible for maintenance. Where possible, install with valve stem axis vertical, with operator side up. Where vertical stem position is not possible, or would result in poor access, valves may be installed with stem horizontal. Do not install valves with stem below horizontal or down.

3.11 SOFTWARE INSTALLATION

A. Point Structuring and Naming
   1. The intent of this Paragraph is to require a consistent means of naming points across the EMCS. The following requirement establishes a standard for naming points and addressing Buildings, Networks, Devices, Instances, etc.

2. Point Summary Table
   a. The term “Point” includes all physical I/O points, virtual points, and all application program parameters.
   b. With each schematic, provide a Point Summary Table listing
      1) Building number and abbreviation
      2) System type
      3) Equipment type
      4) Point suffix
      5) Full point name (see Point Naming Convention Paragraph)
      6) Point description
      7) Ethernet backbone network number,
8) Network number
9) Device ID
10) Device MAC address
11) Object ID (object type, instance number)
12) Engineering units
13) Device make and model number; include range of device if model number does not so identify.
14) Device physical location description; include floor and column line intersection to one decimal place (for example line 6.2 and line A.3).

c. Point Summary Table shall be provided in both hard copy and in a relational database electronic format (ODBC-compliant).

d. Coordinate with the Owner’s representative and compile and submit a proposed Point Summary Table for review prior to any object programming or Project startup.

e. The Point Summary Table shall be kept current throughout the duration of the Project by the Design Builder as the Master List of all points for the Project. Project closeout documents shall include an up-to-date accurate Point Summary Table. The Design Builder shall deliver to the Owner the final Point Summary Table prior to final acceptance of the system. The Point Summary Table shall be used as a reference and guide during the commissioning process.

3. Point Naming Convention

a. All point names shall adhere to the format as established below, unless otherwise agreed to by the Owner. New categories and descriptors may be created with approval of the Owner.

b. Format:


2) Example: 001.HVAC.Heatplant.B-1.HWS.Temperature.
### Building Automation System

**Building Category System Equipment**

<table>
<thead>
<tr>
<th>Building</th>
<th>Category</th>
<th>System</th>
<th>Equipment Tag</th>
<th>Component</th>
<th>Property</th>
<th>Typical units</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Lighting</td>
<td></td>
<td>SWITCH</td>
<td>Command</td>
<td>On/off</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Plug</td>
<td></td>
<td>PHOTO</td>
<td>Status</td>
<td>On/off</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Generator</td>
<td></td>
<td>CB</td>
<td>Light</td>
<td>Footcandles</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Misc</td>
<td></td>
<td></td>
<td>Power</td>
<td>Watts</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ELCT</td>
<td></td>
<td>CWS</td>
<td>Voltage</td>
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<td>HVAC</td>
<td>Weather</td>
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4. **Device Addressing Convention**

a. BACnet network numbers and Device Object IDs shall be unique throughout the network.

b. All assignment of network numbers and Device Object IDs shall be coordinated with the Owner.

c. Each Network number shall be unique throughout all facilities and shall be assigned in the following manner:

1) BBBFF, where: BBB = 1-655 assigned to each building, FF = 00 for building backbone network, 1-35 indicating floors or separate systems in the building.

d. Each Device Object Identifier property shall be unique throughout the system and shall be assigned in the following manner:

1) XXFFBBB, where: XX = number 0 to 40, FF = 00 for building backbone network, 1-35 indicating floors or separate systems in the building. BBB = 1-655 assigned to each building.

e. Coordinate with the Owner or a designated representative to ensure that no duplicate Device Object IDs occur.
Alternative Device ID schemes or cross-project Device ID duplication if allowed shall be approved before Project commencement by the Owner.

5. I/O Point Physical Description
   a. Each point associated with a hardware device shall have its BACnet long-name point description field filled out with:
      1) The device manufacturer and model number. Include range of device if model number does not so identify.
      2) For space sensors, include room number in which sensor is located.

B. Point Parameters
   1. Provide the following minimum programming for each analog input
      a. Name
      b. Address
      c. Scanning frequency or COV threshold
      d. Engineering units
      e. Offset calibration and scaling factor for engineering units
      f. High and low value reporting limits (reasonableness values), which shall prevent control logic from using shorted or open circuit values.
      g. Default value to be used when the actual measured value is not reporting. This is required only for points that are transferred across the primary or secondary controlling networks and used in control programs residing in control units other than the one in which the point resides. Events causing the default value to be used shall include failure of the control unit in which the point resides or failure of any network over which the point value is transferred.
      h. Selectable averaging function that shall average the measured value over a user selected number of scans for reporting.
   2. Provide the following minimum programming for each analog output
      a. Name
      b. Address
      c. Output updating frequency
      d. Engineering units
e. Offset calibration and scaling factor for engineering units
f. Output Range
g. Default value to be used when the normal controlling value is not reporting.

3. Provide the following minimum programming for each digital input
   a. Name
   b. Address
c. Engineering units (on/off, open/closed, freeze/normal, etc.)
d. Debounce time delay
e. Message and alarm reporting as specified
f. Reporting of each change of state, and memory storage of the time of the last change of state
g. Totalization of on-time (for all motorized equipment status points), and accumulated number of off-to-on transitions.

4. Provide the following minimum programming for each digital output
   a. Name
   b. Address
c. Output updating frequency
d. Engineering units (on/off, open/closed, freeze/normal, etc.)
e. Direct or Reverse action selection
f. Minimum on-time
g. Minimum off-time
h. Status association with a DI and failure alarming (as applicable)
i. Reporting of each change of state, and memory storage of the time of the last change of state.
j. Totalization of on-time (for all motorized equipment status points), and accumulated number of off-to-on transitions.
k. Default value to be used when the normal controlling value is not reporting.
C. Site-Specific Application Programming

1. All site specific application programming shall be written in a manner that will ensure programming quality and uniformity. Design Builder shall ensure:
   a. Programs are developed by one programmer, or a small group of programmers with rigid programming standards, to ensure a uniform style.
   b. Programs for like functions are identical, to reduce debugging time and to ease maintainability.
   c. Programs are thoroughly debugged before they are installed in the field.

2. Massage and tune application programming for a fully functioning system. It is the Design Builder’s responsibility to request clarification on sequences of operation that require such clarification.

3. All site-specific programming shall be fully documented and submitted for review and approval:
   a. Prior to downloading into the panel (see Submittal Package 2, Paragraph 1.6.)
   b. At the completion of functional performance testing, and
   c. At the end of the warranty period (see Warranty Maintenance, Paragraph 1.11).

4. All programming, graphics and data files must be maintained in a logical system of directories with self-explanatory file names. All files developed for the Project will be the property of the Owner and shall remain on the workstations/servers at the completion of the Project.

D. Graphic Screens

1. All site specific graphics shall be developed in a manner that will ensure graphic display quality and uniformity among the various systems.

2. Schematics of MEP systems
   a. Schematics shall be 2-D or 3-D and shall be based substantially on the schematics provided on Drawings.
   b. All relevant I/O points and setpoints being controlled or monitored for each piece of equipment shall be displayed with the appropriate engineering units. Include appropriate engineering units for each displayed point value. Verbose names (English language descriptors) shall be included for each point on all graphics; this may be accomplished by the use of a pop-up window accessed by selecting the displayed point with the mouse.
c. Animation or equipment graphic color changes shall be used to indicate on/off status of mechanical components.

d. Indicate all adjustable setpoints and setpoint high and low limits (for automatically reset setpoints), on the applicable system schematic graphic or, if space does not allow, on a supplemental linked-setpoint screen.

3. Displays shall show all points relevant to the operation of the system, including setpoints and setpoint limits for setpoints that are automatically reset.

4. The current value and point name of every I/O point and setpoint shall be shown on at least one graphic and in its appropriate physical location relative to building and mechanical systems.

5. Show weather conditions (local building outside air temperature and humidity) in the upper left hand corner of every graphic.

6. CAD Files: The contract document drawings will be made available to the Design Builder in AutoCAD Release 2015 format upon request for use in developing backgrounds for specified graphic screens, such as floor plans and schematics. However the Owner does not guarantee the suitability of these drawings for the Design Builder’s purpose.

7. Update existing and provide new to reflect the actual installation. Correct the existing graphics on items covered by this project.

a. Central plant equipment including chilled water system, cooling tower system, hot water system, steam system, generators, etc.: The flow path shall change on the diagram (by changing piping line color or width) to show which piping has active flow into each boiler, chiller, tower, etc. as valve positions change.

b. Summary graphics: Provide a single text-based page (or as few as possible) for each of the following summary screens showing key variables listed in columns for all listed equipment. Include hyperlinks to each zone imbedded in the zone tag:

1) Air handling units: operating mode; on/off status; supply air temperature; supply air temperature setpoint; fan speed; duct static pressure; duct static pressure setpoint; outdoor air and return air damper position; coil valve positions; etc. (all key operating variables); Cooling CHWST Reset current requests, cumulative %-request-hours, and request Importance Multiplier; Heating HWST Reset current requests, cumulative %-request-hours, and request Importance Multiplier (if HW coil).

2) VAV Zone terminal units: operating mode; airflow rate; airflow rate setpoint; zone temperature; zone temperature setpoint; damper position; HW valve position (reheat boxes); supply air temperature (reheat boxes); supply air temperature setpoint (reheat boxes); CO2
concentration and CO2 loop output (where applicable); Fan start/stop command, speed, and status (fan-powered); Static Pressure Reset current requests, cumulative %-request-hours, and request Importance Multiplier; Cooling SAT Reset current requests, cumulative % request-hours, and request Importance Multiplier; Heating HWST Reset current requests, cumulative % request-hours, and request Importance Multiplier (HW reheat); Heating Static Pressure Reset current requests, cumulative % request-hours, and request Importance Multiplier (dual duct); Heating SAT Reset current requests, cumulative % request-hours, and request Importance Multiplier (dual duct).

c. For all equipment with runtime alarms specified, show on graphic adjacent to equipment the current runtime, alarm setpoint (adjustable), alarm light, and alarm reset/acknowledge button which resets the runtime counter.

d. For all equipment with lead/lag or lead/standby operation specified, adjacent to equipment the current lead/lag order and manual buttons or switches to allow manual lead

e. All other BAS controlled/monitored equipment.

f. All equipment shall be identified on the graphic screen by the unit tag as scheduled on the drawings.

E. Alarm Configuration

1. Program alarms and alarm levels per Sequence of Operations.

2. Each programmed alarm shall appear on the alarm log screen and shall be resettable or acknowledged from those screens. Equipment failure alarms shall be displayed on the graphic system schematic screen for the system that the alarm is associated with (for example, fan alarm shall be shown on graphic air handling system schematic screen). For all graphic screens, display values that are in a Level 1 or 2 condition in a red color, Level 3 and higher alarm condition in a blue color, and normal (no alarm) condition in a neutral color (black or white).

3. For initial setup, Design Builder shall configure alarms as follows:

<table>
<thead>
<tr>
<th></th>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Level 4 &amp; 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Criticality</td>
<td>Critical</td>
<td>Not Critical</td>
<td>Not Critical</td>
<td>Not Critical</td>
</tr>
<tr>
<td>Acknowledgement</td>
<td>Required</td>
<td>Required</td>
<td>Not Required</td>
<td>Not Required</td>
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<tr>
<td>Acknowledgement of Return to Normal</td>
<td>Not Required</td>
<td>Not Required</td>
<td>Not Required</td>
<td>Not Required</td>
</tr>
<tr>
<td>Print to alarm printer</td>
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<td>Y</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Email to building engineer(s)</td>
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<td>Y</td>
<td>N</td>
</tr>
</tbody>
</table>
### 3.12 CHECKOUT AND TESTING

**A.** The BAS Design Builder shall provide a 48 hour notice to the commissioning agent and the Owner to provide both parties the opportunity to witness any or all of the work. Commissioning activities performed without notice may not be accepted by the Owner.

**B.** The BAS Design Builder shall develop all the pre-functional and functional performance test sheets and submit for approval.

**C.** The pre-functional tests for the primary system such as the chillers, boiler AHU's and related equipment will be an end to end point check that has to be performed with the operational GUI tested from the point of origin to the GUI graphic.

1. Valves (modulating or floating) need to be stroked fully open to fully closed. Verify that the speed of actuation is appropriate for the application and the rated speed of the actuator is achieved. Visual inspection of the open and closed position.

2. Dampers (modulating or floating) need to be stroked fully open to fully closed. Verify that the speed of actuation is appropriate for the application and the rated speed of the actuator is achieved. Visual inspection of the open and closed position.

3. Solenoids need to be stroked open to closed. Visual inspection of the open and closed position.

4. All sensors, such as temperature, humidity pressure or other specialty sensors need to be calibrated and the offset values noted in the test. Sensors found to be outside their specified accuracy range shall be replaced. Calibration to be verified with NIST traceable instruments.

5. Check each alarm separately by including an appropriate signal at a value that will trip the alarm.

6. Interlocks shall be tripped using field contacts to check the logic, as well as to ensure that the fail-safe condition for all actuators is in the proper direction.

7. Verify that all control wiring is properly connected and free of all shorts and ground faults and verify that terminations are tight.

8. Tune all DDC loops.

**D.** The functional tests for the system shall be designed to verify the sequence of operation as approved by the Owner. The test shall simulate at least one full cycle of operation to observe an equipment startup and shutdown cycle and a normal use period. It shall include a test for all...
associate safeties. For equipment operated 24 hours, the equipment shut down and start up shall be done manually via the GUI. All other control functions shall be in automatic mode. The verification shall be end to end for each piece of equipment with the operational GUI tested from the point of origin to the GUI graphic.

E. As a minimum, the systems shall trend all physical I/O's and all set-points. Digital values shall be trended on a COV basis. Analog values shall be trended based at 1 minute intervals or based on a 1% change of full range.

3.13 DEMONSTRATION

A. Prior to acceptance, the control system shall undergo a series of performance tests to verify operation and demonstrate compliance with this specification. The Demonstration shall occur after all work has been completed and the tests as defined under "Checkout and Testing" have been concluded. The Owner's Representative shall be present to observe and review the Demonstration.

B. The Design Buiers shall provide an adequate number of personnel, each equipped with two-way communication, and shall demonstrate actual field operation of each control and sensing point for all modes of operation including, but not limited to; day, night, occupied, unoccupied, fire/smoke alarm, seasonal changeover, and power failure modes. The purpose is to demonstrate the calibration, response, and action of every point/object and system. Any test equipment required to prove the proper operation shall be provided by and operated by the Division 23, Division 25 and Division 26 Design Builders.

C. As each control input and output is checked, a log shall be completed showing the date, technician's initials, and any corrective action taken or needed.

D. Demonstrate compliance with sequences of operation through all modes of operation.

E. Demonstrate that the Owner approved alarm annunciation and escalation for all system and applications alarms work as submitted during the submittal phase.

F. Additionally, the following items shall be demonstrated:

1. DDC Loop Response. The Design Builder shall supply trend data output in a graphical form showing the step response of each DDC loop. The test shall show the loop's response to a change in set-point, which represents a change of actuator position of at least 25% of its full range. The sampling rate of the trend shall be from 10 seconds to 3 minutes, depending on the speed of the loop. The trend data shall show for each sample the set-point, actuator position, and controlled variable values. Any loop that yields unreasonably under-damped or over-damped control shall require further tuning by the appropriate Division 23 or Division 25 Design Builder.

2. Demand Limiting. The Design Builder shall supply a trend data output showing the action of any demand-limiting algorithm. The data shall document the action on a minute-by-minute basis over at least a 30-minute period. Included in the trend shall be building kW, demand limiting set-point, and the status of shedding equipment outputs.
3. Optimum Start/Stop. The Design Builder shall supply a trend data output showing the capability of the algorithm. The hour-by-hour trends shall include the output status of all optimally started and stopped equipment, as well as temperature sensor inputs of affected areas.

4. Operational logs for each system that indicate all set-points, operating points, valve positions, mode, and equipment status shall be submitted to the engineer and Owner’s Representative. These logs shall cover three 48-hour periods and have a sample frequency of not more than 10 minutes. The logs shall be provided in a printed graphical format.

3.14 SYSTEM ACCEPTANCE

A. The Division 23, 25 and 26 Design Builders are to coordinate the Demonstration of the system such that each Division has a representative present during the activities.

B. Prior to acceptance, the control system shall undergo a series of performance tests to verify operation and demonstrate compliance with this specification. The Demonstration shall occur after the Division 23, 25 and 26 Design Builders have completed their tests as defined under "Checkout and Testing". The Owner’s Representative shall be present to observe and review the Demonstration.

C. The Demonstration process shall utilize the forms and follow the processes previously defined as part of the Division 23, 25 and 26 Design Builder’s submittals. The approved checklists and forms shall be completed for all systems as part of the Demonstration.

D. The Design Builder shall provide an adequate number of personnel, each equipped with two-way communication, and shall demonstrate actual field operation of each control and sensing point for all modes of operation including, but not limited to; day, night, occupied, unoccupied, fire/smoke alarm, seasonal changeover, and power failure modes. The purpose is to demonstrate the calibration, response, and action of every point/object and system. Any test equipment required to prove the proper operation shall be provided by and operated by the Division 23,25 and 26 Design Builders.

E. As each control input and output is checked, a log shall be completed showing the date, technician's initials, and any corrective action taken or needed.

F. Demonstrate compliance with sequences of operation through all modes of operation.

G. Additionally, the following items shall be demonstrated:

1. DDC Loop Response. The Design Builder shall supply trend data output in a graphical form showing the step response of each DDC loop. The test shall show the loop's response to a change in set-point, which represents a change of actuator position of at least 25% of its full range. The sampling rate of the trend shall be from 10 seconds to 3 minutes, depending on the speed of the loop. The trend data shall show for each sample the set-point, actuator position, and controlled variable values. Any loop that yields unreasonably under-damped or over-damped control shall require further tuning by the appropriate Division 23,25 or Division 26 Design Builder.
2. Demand Limiting. The Design Builder shall supply a trend data output showing the action of any demand-limiting algorithm. The data shall document the action on a minute by minute basis over at least a 30-minute period. Included in the trend shall be building kW, demand limiting set-point, and the status of load shedding equipment outputs.

3. Optimum Start/Stop. The Design Builder shall supply a trend data output showing the capability of the algorithm. The hour-by-hour trends shall include the output status of all optimally started and stopped equipment, as well as temperature sensor inputs of affected areas.

4. Operational logs for each system that indicate all set-points, operating points, valve positions, mode, and equipment status shall be submitted to the engineer and Owner's Representative. These logs shall cover three 48-hour periods and have a sample frequency of not more than 10 minutes. The logs shall be provided in a printed graphical format.

H. Any tests that fail to demonstrate the operation of the system shall be repeated as soon as possible. The Design Builder shall be responsible for any necessary repairs or revisions to the hardware or software they each have provided to successfully complete all tests.

3.15 OPERATOR INSTRUCTION, TRAINING

A. During system commissioning, and at such time as the acceptable performance of the BAS hardware and software has been established, the BAS Design Builder and the integrations Design Builder shall provide on-site operator instruction to the Owner's operating personnel. Operator instruction shall be done during normal working hours and shall be performed by a competent representative familiar with the system hardware, software and accessories.

B. Provide 40 hours of combined instruction to the Owner's designated personnel on the operation of the BAS and describe its intended use with respect to the programmed functions specified. Operator orientation of the BAS shall include, but not be limited to; the overall operation program, equipment functions (both individually and as part of the total integrated system), commands, systems generation, advisories, and appropriate operator intervention required in responding to the system's operation.

C. The training shall be in three sessions as follows:

1. Initial Training: One day session (8 hours) after system is started up and at least one week before first acceptance test. Instruction & Operations manuals shall have been submitted at least two weeks prior to training so that the Owner's personnel can start to familiarize themselves with the system before classroom instruction begins.

2. First Follow-Up Training: Two days (16 hours total) approximately one months after conclusion of the functional performance test but before formal acceptance. These sessions will deal with more advanced topics and answer questions from the users

3. Warranty Follow Up: Two days (16 hours total) in no less than 4 hour increments, to be scheduled at the request of the Owner during the one year warranty period. These
sessions shall cover topics as requested by the Owner such as; how to add additional points, create and gather data for trends, graphic screen generation or modification of control routines.

4. The Design Builder shall provide an agenda and the content covered in writing and/or via PowerPoint presentation one week before the training session. Informal training sessions without detailed agenda and appropriate documentation about topics covered are not acceptable.

5. In addition to the 40 hours of training mentioned earlier in this section, the Design Builder shall provide factory training for at least 4 designated Owner's representatives at the site by a factory representative. The training shall cover all aspects of programming and configuration of the systems including all controllers, network management devices and Graphic User Interface.

3.16 STANDARD REPORTS

A. As a minimum, the following reports shall be available to the Owner:

B. A report that will run automatically at an interval chosen by the operator, listing any software or hardware point in override or disabled (separate with that distinction) at the time of the report generation. Any point in override shall be shown with the time, date and user that put the point into override and with the time remaining in override. The user shall be able to send the report to a screen, pdf file with a unique file name architecture that includes the date and time or a designated printer.

1. A report that will run automatically at an interval chosen by the Owner that will list the point status. As a minimum, the status shall include the current value, the point name the point description with the related Engineering unit and the time and date stamp

2. A report that will run automatically at an interval chosen by the Owner that will list all points in alarm. At a minimum, each alarm shall include the current value, the point name the point description with the related Engineering unit and the alarm message with time and date stamp. The Owner shall be able to select system alarms and application alarms separately to allow him/her to keep separate logs. System alarms are defined as alarms that are generated by the system indicating and issue with the status of the system hardware and software such as controller issue, communication issues, power issues, soft and hard reboots, and diagnostics. Application alarms are defined as alarms related to the specific nature of the equipment controlled such as status alarms, temperature or humidity levels or any other alarm that is specific to the application programmed in the controller. See materials section for additional information.

C. All time and date stamps for reports shall includes the exact time in format such as 12:02:52 AM.
3.17 RECORD DOCUMENTATION

A. Three copies of the Operation & Maintenance manuals for work provided under this Division shall be provided to the Owner upon completion of the project. These manuals shall be updated each time changes are made to the system. The entire Operation & Maintenance manual shall be furnished in three-ring binders with adequate indexing and with identical indexing and format in pdf, provided on CD or DVD media. As a minimum it shall include the following:

1. Table of contents.

2. As-built system record drawings. Record drawings in AutoCAD format shall represent the as-built condition of the system and incorporate all information supplied with the approved submittals. These shall include the sequences of operation and a complete I/O point summary.

3. Manufacturer’s products O&M sheets for all products including software.

4. System operator’s manuals. This manual shall be specific for the installation and include any information need for the operator to use the system effectively.

5. Complete network diagrams that also indicate connections to the BAS Wide Area Network on the Owner provided network.

6. Wiring termination schedules.

7. Copies of all completed forms for control system Checkout and Testing and Demonstration activities including hard copies of all trend log graphs.

8. Archive copy of all controller databases, including all field controllers and NAC’s that includes the post commissioning programming at the time of system acceptance (on CD or DVD only).

PART 4 - SEQUENCE OF OPERATION

4.01 SEE CONTRACT DRAWINGS FOR FURTHER DETAILS

4.02 SEQUENCES OF OPERATION

A. General

1. Design Builder shall review sequences prior to programming and suggest modifications where required to achieve the design intent. Design Builder may also suggest modifications to improve performance and stability or to simplify or reorganize logic in a manner that provides equal or better performance.

2. Unless otherwise indicated in SOOs, control loops shall be enabled and disabled based on the status of the system being controlled to prevent wind-up.
3. When a control loop is enabled or re-enabled, it and all its constituents (such as the proportional and integral terms) shall be set initially to a Neutral value.

4. A control loop in Neutral shall correspond to a condition that applies the minimum control effect, i.e., valves/dampers closed, VFDs at minimum speed, etc.

5. When there are multiple outdoor air temperature sensors, the system shall use the valid sensor that most accurately represents the outdoor air conditions at the equipment being controlled.
   a. Outdoor air temperature sensors at air handler outdoor air intakes shall be considered valid only when the supply fan is proven on and unit is in Occupied Mode or in any other Mode with the economizer enabled.
   b. The outdoor air temperature used for optimum start, plant lockout, and other global sequences shall be the average of all valid sensor readings. If there are four or more valid outdoor air temperature sensors, discard the highest and lowest temperature readings.

6. The term “proven” (i.e. “proven on”/“proven off”) shall mean that the equipment’s DI status point matches the state set by the equipment’s DO command point.

7. The term “software point” shall mean an analog variable, and “software switch” shall mean a digital (binary) variable, that are not associated with real I/O points. They shall be read/write capable (e.g., BACnet analog variable and binary variable).

8. The term “PID loop” or “control loop” is used generically for all control loops and shall not be interpreted as requiring proportional plus integral plus derivative gains on all loops. Unless specifically indicated otherwise, the following guidelines shall be followed:
   a. Use proportional only (P-only) loops for limiting loops (such as zone CO2 limiting loops, etc.) to ensure there is no integral windup.
   b. Do not use the derivative term on any loops unless field tuning is not possible without it.

9. To avoid abrupt changes in equipment operation, the output of every control loop shall be capable of being limited by a user adjustable maximum rate of change, with a default of 25% per minute.

10. All setpoints, timers, deadbands, PID gains, etc. listed in sequences shall be capable of being adjusted by the operator without having to access programming whether indicated as adjustable in sequences or not. Software (virtual) points shall be used for these setpoints. Fixed scalar numbers shall not be imbedded in programs unless the value will never need to be adjusted.

11. Values for all points, including real (hardware) points used in control sequences shall be capable of being overridden by the user (e.g. for testing and commissioning). If
hardware design prevents this for hardware points, they shall be equated to a software point and the software point shall be used in all sequences. Exception: Not required for ASC hardware points.

12. Alarms

a. There shall be 4 levels of alarm

1) Level 1: Life Safety Message
2) Level 2: Critical Equipment Message
3) Level 3: Urgent Message
4) Level 4: Normal Message

5) Maintenance Mode: Operators shall have the ability to put any device (e.g., AHU) in/out of maintenance mode via switch on graphics.
   a) All alarms associated with a device in maintenance mode will be suppressed
      i) Exception: Life safety alarms shall not be suppressed.
   b) If a device is in maintenance mode, issue a daily level 3 alarm at a scheduled time, indicating the device is still in maintenance mode.

6) Entry Delays – All alarms shall have an adjustable delay time such that the alarm is not triggered unless the alarm condition is true for the delay time. Default entry delays:
   a) Level 1 alarms: 1 second
   b) Level 2 alarms: 10 seconds
   c) Level 3 alarms: 1 minute
   d) Level 4: 5 minutes

7) Exit Deadbands – All alarms on analog inputs shall have an adjustable deadband for both the input variable and time – e.g., if the SAT alarm is triggered at 85°F for 5 minutes, then the alarm does not restore to normal until the SAT drops below the alarm setpoint minus a deadband of 2°F for 5 minutes. Default exit deadband: 0% below alarm threshold for 5 seconds.

8) Latching – Any alarm can be configured as latching or non-latching. A latching alarm requires acknowledgement from the operators before it can return to normal even if the exit deadband has been met. A non-latching alarm does not require acknowledgement. Default latching status:
   a) Level 1 alarms: latching
   b) Level 2 alarms: latching
   c) Level 3 alarms: non-latching
d) Level 4 alarms: non-latching.

9) Post Exit Suppression period – To limit alarms, any alarm may have an adjustable suppression period such that a particular instance of that alarm may not re-occur until the alarm has been cleared for the suppression period. Default suppression periods:
  a) Level 1 alarms: 0 minutes
  b) Level 2 alarms: 5 minutes
  c) Level 3 alarms: 24 hours
  d) Level 4 alarms: 7 days.

10) For both latching and non-latching alarms, the operators may acknowledge the alarm. Acknowledging an alarm clears the alarm, the exit deadband, and suppression period. A device can go right back into alarm as soon as the entry delay elapses.

13. VFD Speed Points

a. The speed analog output sent to VFDs shall be configured such that 0% speed corresponds to 0 Hz and 100% speed corresponds to maximum speed configured in the VFD.

b. For each piece of equipment, the minimum speed shall be stored in a single software point. This value shall be written to the VFD’s minimum speed setpoint every 15 minutes via the drive’s network interface; in the case of a hard-wired VFD interface, the minimum speed shall be the lowest speed command sent to the drive by the BAS. See 3.2A.2 for minimum speed setpoints.

14. Trim & Respond Setpoint Reset Logic

a. Trim & Respond setpoint reset logic and zone/system reset requests where referenced in sequences shall be implemented as described below.

b. “Requests” are pressure, cooling, or heating setpoint reset requests generated by zones or air handling systems.

1) For each zone or system, and for each setpoint reset request type

2) listed for the zone/system, provide the following software points:
   a) Importance Multiplier (default = 1). This point is used to scale the number of requests the zone/system is generating. A value of zero causes the zone/system’s requests to be ignored. A value greater than zero can be used to effectively increase the number of requests from the zone/system based on the critical nature of the spaces served, or to increase the requests beyond the number of ignored requests (defined below) in the Trim & Respond reset block.
   b) Request-hours
i) This point accumulates the integral of requests (prior to adjustment of Importance Multiplier) to help identify zones/systems that are driving the reset logic. Every x minutes (adjustable, default 5 minutes), add x/60 times the current number of requests to this request-hours accumulator point.

ii) The request-hours point is reset to zero upon a global command from the system/plant serving the zone/system – this global point simultaneously resets the request-hours point for all zones/systems served by this system/plant.

iii) Cumulative %-request-hours is the zone request-hours divided by the zone run-hours (the hours in any Mode other than Unoccupied Mode) since the last reset, expressed as a percentage.

iv) A Level 4 alarm is generated if the zone Importance Multiplier is greater than zero, the zone %-request-hours exceeds 70%, and the total number of zone run-hours exceeds 40.

c) See zone and air handling system control sequences for logic to generate requests.

d) Multiply the number of requests determined from zone/system logic times the Importance Multiplier and send to the system/plant that serves the zone/system. See system/plant logic to see how requests are used in Trim & Respond logic.

c. Variables. All variables below shall be adjustable from a reset graphic accessible from a hyperlink on the associated system/plant graphic. Initial values are defined in system/plant sequences below. Values for trim, respond, time step, etc. shall be tuned to provide stable control.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>SP0</td>
<td>Initial setpoint</td>
</tr>
<tr>
<td>SP_min</td>
<td>Minimum setpoint</td>
</tr>
<tr>
<td>SP_max</td>
<td>Maximum setpoint</td>
</tr>
<tr>
<td>Td</td>
<td>Delay timer</td>
</tr>
<tr>
<td>T</td>
<td>Time step</td>
</tr>
<tr>
<td>I</td>
<td>Number of ignored requests</td>
</tr>
<tr>
<td>R</td>
<td>Number of requests from zones/systems</td>
</tr>
<tr>
<td>SPtrim</td>
<td>Trim amount</td>
</tr>
<tr>
<td>SP_res</td>
<td>Respond amount</td>
</tr>
<tr>
<td>SP_res-max</td>
<td>Maximum response per time interval</td>
</tr>
</tbody>
</table>

d. Trim & Respond logic shall reset setpoint within the range SP_min to SP_max. When the associated device (e.g. fan, pump) is off, the setpoint shall be SP0. The reset logic shall be active while the associated device is proven on, starting Td after initial device start command. When active, every time step T, trim the setpoint by SPtrim. If there are more than I Requests, respond by changing the setpoint by SP_res times (R – I), i.e. (the number of Requests
minus the number of Ignored requests). But the net response shall be no more than SPres-max. The sign of SPtrim must be the opposite of SPres and SPres-max. For example, if SPtrim = -0.1, SPres = +0.15, SPres-max = +0.35, \( R = 3, I = 2 \), then each time step, the setpoint change = \(-0.1 + (3-2)*0.15 = +0.05\). If \( R=10 \), then setpoint change = \(-0.1 + (10-2)*0.15 = 1.1 \) but limited to a maximum of 0.35. If \( R\leq2 \), the setpoint change is -0.1.

15. Lead/lag and lead/standby alternation

a. Even Wear

1) Lead/lag. Unless otherwise noted, parallel staged devices (such as pumps, towers) shall be lead/lag alternated when more than one is off or more than one is on so that the device with the most operating hours is made the later stage device and the one with the least number of hours is made the earlier stage device. For example, assuming there are three devices, if all three are off or all are on, the staging order will simply be based on run hours from lowest to highest. If two devices are on, the one with the most hours will be set to be stage 2 while the other is set to stage 1; this may be the reverse of the operating order when the devices were started. If two devices are off, the one with the most hours will be set to be stage 3 while the other is set to stage 2; this may be the reverse of the operating order when the devices were stopped.

2) Lead/standby. Unless otherwise noted, parallel devices (such as pumps, towers) that are 100% redundant shall be lead/standby alternated when more than one is off so that the device with the most operating hours is made the later stage device and the one with the least number of hours is made the earlier stage device. For example, assuming there are three devices, if all three are off, the staging order will be based on run hours from lowest to highest. If devices run continuously, lead/standby shall switch at an adjustable runtime; standby device shall first be started and proven on before former lead device is changed to standby and shut off.

b. Exceptions

1) Operators shall be able to manually fix staging order via software points on graphics overriding the Even Wear logic above, but not overriding the Failure or Hand Operation logic below.

2) Failure: If the lead device fails or has been manually switched off, the device shall be placed into high level alarm (Level 2) and set to the last stage position in the lead/lag order until alarm is reset by operator. Staging position of remaining devices shall follow the Even Wear logic. A failed device in alarm can only automatically move up in the staging order if another device fails. Note that a device in alarm will be commanded to run if the sequence calls for it to run. In this way the
EMCS will keep trying to run device(s) until it finds enough that will operate. Failure is determined by:

a) Variable Speed Fans and Pumps
   i) VFD critical fault is ON
   ii) Status point not matching its on/off point for 15 seconds when device is commanded on
   iii) Supervised HOA at control panel in OFF position
   iv) Loss of power (e.g. VFD DC Bus voltage = zero)

b) Constant Speed Fans and Pumps
   i. Status point not matching its on/off point for 15 seconds when device is commanded on
   ii. Supervised HOA at control panel in OFF position

c) Chillers
   i) Chiller alarm contact
   ii) Chiller is manually shut off as indicated by the status of the Local/Auto switch from chiller gateway.
   iii) Chiller status remains off 5 minutes after command to start

d) Boilers
   i) Boiler alarm point is ON
   ii) If its leaving water temperature remains 15°F below setpoint for 30 minutes

3) Hand Operation. If a device is on in Hand (for example via an HOA switch or local control of VFD), the device shall be set to the lead device and a low level alarm (Level 4) shall be generated. The device will remain as lead until the alarm is reset by the operator. Hand operation is determined by

a) Variable Speed Fans and Pumps
   i) Status point not matching its on/off point for 15 seconds when device is commanded off
   ii) VFD in local “hand” mode
   iii) Supervised HOA at control panel in ON position

b) Constant Speed Fans and Pumps
   i) Status point not matching its on/off point for 15 seconds when device is commanded off
   ii) Supervised HOA at control panel in ON position

c) Chillers: Chiller is manually turned on as indicated by the status of the Local/auto switch from chiller gateway.

16. VAV Box Controllable Minimum

a. This section is used to determine the lowest possible VAV box airflow setpoint allowed by the controls (Vm) used in VAV box control sequences. The minimums shall be stored as software points.

b. Option 1: If the VAV box controls simply stop moving the damper when the airflow reading becomes too low to register and then re-enables the damper when the airflow reading rises above that threshold, Vm shall be equal to zero.
c. Option 2: The minimum setpoint Vm shall be determined as follows:

1) Determine the velocity pressure sensor reading VPM in inches H2O that will give a reliable flow indication. If this information is not provided by the sensor manufacturer, determine the velocity pressure that will result in a digital reading from the transducer and A/D converter of 12 bits or counts (assuming a 10 bit A/D converter). This is considered sufficient resolution for stable control.

2) Determine the minimum velocity v_m for each VAV box size and model. If the VAV box manufacturer provides an amplification factor F for the flow pickup, calculate the minimum velocity Vm as

\[ Vm = \frac{VPM}{F} \]

Where F is not known, it can be calculated from the measured airflow at 250 Pa (1 inch w.c.) signal from the VP sensor

\[ F = \left( \frac{4005A}{CFM @ 1'} \right)^2 \]

where A is the nominal duct area (ft^2), equal to

\[ A = \pi \left( \frac{D}{24} \right)^2 \]

where D is the nominal duct diameter (inches).

3) Calculate the minimum airflow setpoint allowed by the controls (Vm) for each VAV box size as

\[ Vm = v_m A \]
17. Air Economizer High Limits

a. Economizer shall be disabled whenever the outdoor air conditions exceed the economizer high limit setpoint as specified by local code. Setpoints vary by energy standard, climate zone, and economizer high limit control device type. Setpoints listed below are for current ASHRAE and California Energy Standards.

b. Title 24-2016

<table>
<thead>
<tr>
<th>Device Type</th>
<th>California Climate Zones</th>
<th>Required High Limit (Economizer Off When):</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed Dry Bulb</td>
<td>1, 3, 5, 11-16</td>
<td>TOA &gt; 24°C (75°F)</td>
</tr>
<tr>
<td></td>
<td>2, 4, 10</td>
<td>TOA &gt; 23°C (73°F)</td>
</tr>
<tr>
<td></td>
<td>6, 8, 9</td>
<td>TOA &gt; 22°C (71°F)</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>TOA &gt; 21°C (69°F)</td>
</tr>
<tr>
<td>Differential Dry Bulb</td>
<td>1, 3, 5, 11-16</td>
<td>TOA &gt; TRA</td>
</tr>
<tr>
<td></td>
<td>2, 4, 10</td>
<td>TOA &gt; TRA – 1.1°C (2°F)</td>
</tr>
<tr>
<td></td>
<td>6, 8, 9</td>
<td>TOA &gt; TRA – 2.2°C (4°F)</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>TOA &gt; TRA – 3.3°C (6°F)</td>
</tr>
<tr>
<td>Fixed Enthalpy + Fixed Drybulb</td>
<td>All</td>
<td>hOA &gt; 66 kJ/kg (28 Btu/lb) or TOA &gt; 24°C (75°F)</td>
</tr>
</tbody>
</table>

18. Hierarchical Alarm Suppression

a. For each piece of equipment or space controlled by the BAS, define its relationship (if any) to other equipment in terms of “source,” “load,” or “system.”

1) A component is a “source” if it provides resources to a downstream component, such as a chiller providing chilled water to an AHU.

2) A component is a “load” if it receives resources from an upstream component, such as an AHU that receives chilled water from a chiller.

3) The same component may be both a load (receiving resources from an upstream source) and a source (providing resources to a downstream load).
4) A set of components is a “system” if they share a load in common (i.e., collectively act as a source to downstream equipment, such as a set of chillers in a lead/lag relationship serving air handlers).
   a) If a single component acts as a source for downstream loads (e.g., an AHU as a source for its VAV boxes), then that single source component shall be defined as a “system” of one element.
   b) For equipment with associated pumps (chillers, boilers, cooling towers).
      i) If the pumps are in a one-to-one relationship with equipment they serve, the pumps shall be treated as part of the system to which they are associated (i.e., they are not considered loads) since a pump failure will necessarily disable its associated equipment.
      ii) If the pumps are headered to the equipment they serve, then the pumps may be treated as a system, which is a load relative to the upstream equipment (e.g., chillers) and a source relative to downstream equipment (e.g., air handlers).

b. For each system as defined above, there shall be a SystemOK flag, which is either true or false.

c. System OK shall be true when all of the following are true:
   1) The system is proven on.
   2) The system is achieving its temperature and/or pressure setpoint(s) for at least five minutes
   3) The system is ready and able to serve its load.

d. SystemOK shall be false while the system is starting up (i.e., before reaching setpoint) or when enough of the system’s components are unavailable (in alarm, disabled, or turned off) to disrupt the ability of the system to serve its load. This threshold shall be defined by the design engineer for each system.
   1) By default, Level 1 through Level 3 component alarms (indicating equipment failure) shall inhibit SystemOK. Level 4 component alarms (maintenance and energy efficiency alarms) shall not affect SystemOK.
   2) The operator shall have the ability to individually determine which component alarms may or may not inhibit SystemOK.

e. The BAS shall selectively suppress (i.e., fail to announce; alarms may still be logged to a database) alarms for load components if SystemOK is false for the source system that serves that load.
1) If SystemOK is false for a cooling water system (i.e., chiller, cooling tower, or associated pump) then only high temperature alarms from the loads shall be suppressed.

2) If SystemOK is false for a heating water system (i.e., boiler or associated pump) then only low temperature alarms from the loads shall be suppressed.

3) If SystemOK is false for an airside system (air handler, fan coil, VAV box, etc.), then all alarms from the loads shall be suppressed.

f. This hierarchical suppression shall cascade through multiple levels of load-source relationship, such that alarms at downstream loads shall also be suppressed.

g. The following types of alarms will never be suppressed by this logic:

1) Life/safety and Level 1 alarms

2) Failure-to-start alarms (i.e., equipment is commanded on, but status point shows equipment to be off)

3) Failure-to-stop/hand alarms (i.e., equipment is commanded off, but status point shows equipment to be on).

19. Time-Based Suppression

a. Calculate a time delay period after any change in setpoint based on the difference between the controlled variable (e.g., zone temperature) at the time of the change and the new setpoint. The default time delay period shall be:

1) For thermal zone temperature alarms: 10 minutes per °F of difference, but no longer than 120 minutes.

2) For thermal zone temperature cooling requests: 5 minutes per °F of difference, but no longer than 30 minutes.

3) For thermal zone temperature heating requests: 5 minutes per °F of difference, but no longer than 30 minutes.

B. Thermal Zones

1. This section applies to all single zone systems and sub-zones of air handling systems, such as VAV boxes, etc.

2. Zone Minimum Outdoor Air and Minimum Airflow Setpoints
a. For every zone that requires mechanical ventilation, the zone minimum outdoor airflows and setpoints shall be calculated depending on the governing standard or code for outdoor air requirements. Zones that do not require mechanical ventilation may disregard this section.

b. See ASHRAE G.36 section 3.1B for zone minimum airflow setpoint, Vmin.

c. The occupied minimum airflow Vmin* shall be equal to Vmin.

d. For compliance with California Title 24, outdoor air setpoints shall be calculated as follows:

1) See 3.1A.2.b for zone ventilation setpoints.

2) Determine the zone minimum outdoor air setpoints Zone-Abs-OA-min and Zone-Des-OA-min.

   a) Zone-Abs-OA-min shall be reset based on the following conditions in order from higher to lower priority:

      i) Zero if the zone has a window switch and the window is open

      ii) 25% of Varea-min if the zone has an occupancy sensor and is unpopulated

      iii) Varea-min if the zone has a CO2 sensor

      iv) Zone-Des-OA-min otherwise

   b) Zone-Des-OA-min is equal to

      i) Zero if the zone has a window switch and the window is open

      ii) 25% of Varea-min if the zone has an occupancy sensor and is unpopulated

      iii) The larger of Varea-min and Vocc-min otherwise.

3) If the zone has a CO2 sensor

   a) See ASHRAE G36 section 3.1A.3 for CO2 setpoints

   b) During Occupied Mode, a P-only loop shall maintain CO2 concentration at setpoint; reset from 0% at (setpoint minus 200 PPM) and to 100% at setpoint.
c) Loop is disabled and output set to zero when the zone is not in Occupied Mode.

d) For cooling-only VAV terminal units, reheat VAV terminal units, constant volume series fan powered terminal units, dual duct VAV terminal units with mixing control and inlet airflow sensors, dual duct VAV terminal units with mixing control and a discharge airflow sensor, or dual duct VAV terminal units with cold duct minimum control:

i) The CO2 control loop output shall reset the occupied minimum airflow setpoint (Vmin*) from the zone minimum airflow setpoint Vmin at 0% up to maximum cooling airflow setpoint Vcool-max at 50%, as shown below. The loop output from 50% to 100% will be used at the system level to reset outdoor air minimum; see AHU controls.

![CO2 Control Loop Diagram]

Vcool-max

Vmin

0% 50% 100%

CO2 Control Loop

Vmin*

e) For single zone VAV air handling units:

i) The minimum outdoor air setpoint MinOAsp shall be reset based on the zone CO2 control loop signal from Zone-Abs-OA-min at 0% signal to Zone-Des-OA-min at 100% signal.
3. Setpoints

a. Each zone shall have separate unoccupied and occupied setpoints, and separate heating and cooling setpoint. As a default:

1) VAV zones
   a) The occupied heating setpoint shall be 70°F and the occupied cooling setpoint shall be 74°F in exterior zones and 73°F interior zones.
   b) The unoccupied heating setpoint shall be 60°F and the unoccupied cooling setpoint shall be 90°F.

2) Electrical and mechanical rooms
   a) The unoccupied and occupied heating setpoint shall be 65°F and the unoccupied and occupied cooling setpoint shall be 85°F.

3) IDF and computer rooms
   a) The unoccupied and occupied heating setpoint shall be 65°F and the unoccupied and occupied cooling setpoint shall be 75°F.

b. The software shall prevent

1) The heating setpoint from exceeding the cooling setpoint minus 1°F (in other words the minimum deadband shall be 1°F);
2) The unoccupied heating setpoint from exceeding the occupied heating setpoint; and

3) The unoccupied cooling setpoint from being less than the occupied cooling setpoint.

c. Where the zone has a local occupant adjustable setpoint adjustment knob/button

1) The setpoint adjustment offsets established by the occupant shall be software points that are persistent (e.g., not reset daily), but the actual offset used in control logic shall be adjusted based on limits and modes as describe below.

2) The adjustment shall be capable of being limited in software.

   a) As a default, the active occupied cooling setpoint shall be limited between 22°C (72°F) and 27°C (80°F).

   b) As a default, the active occupied heating setpoint shall be limited between 18°C (65°F) and 22°C (72°F).

3) The active heating and cooling setpoints shall be independently adjustable, respecting the limits and anti-overlap logic described above. If zone thermostat provides only a single setpoint adjustment, then the adjustment shall move both the active heating and cooling setpoints upwards or downwards by the same amount, within the limits described above.

4) The adjustment shall only affect occupied setpoints in Occupied Mode and shall have no impact on setpoints in all other modes.

5) At the onset of demand limiting, the local setpoint adjustment value shall be frozen. Further adjustment of the setpoint by local controls shall be suspended for the duration of the demand limit event.

d. Heating Demand Limit Setpoint Adjustment: The active heating setpoints for all zones shall be decreased when a demand limit is imposed on the associated Zone Group. The operator shall have the ability to exempt individual zones from this adjustment through the normal BAS user interface. Changes due to demand limits are not cumulative.

e. Demand Limit Setpoint Adjustment: Cooling setpoints shall be increased upon demand limit requests from the associated Zone Group.

1) At Demand Limit Level 1, increase current setpoint by 1°F.

2) At Demand Limit Level 2, increase current setpoint by 2°F.
3) At Demand Limit Level 3, increase current setpoint by 4°F.

f. Occupancy sensors. For zones that have an occupancy switch

1) When the switch indicates the space has been unpopulated for 5 minutes continuously during the Occupied Mode, the active heating setpoint shall be decreased by 1.1°C (2°F), and the cooling setpoint shall be increased by 1.1°C (2°F).

2) When the switch indicates that the space has been populated for one minute continuously, the active heating and cooling setpoints shall be restored to their previous values.

g. The operative setpoint shall be determined by the Zone Group’s mode

1) The setpoints shall be the occupied setpoint during Occupied mode, Warm-up mode, and Cool-down mode.

2) The setpoints shall be unoccupied setpoints during Unoccupied mode, Setback mode, and Setup mode.

h. Hierarchy of Setpoint Adjustments: The following adjustment restrictions shall prevail in order from highest to lowest priority:

1) Setpoint overlap restriction (Paragraph 3.15C.2.b.1))

2) Demand limit.

3) Occupancy sensors.

4) Local setpoint adjustment

5) Scheduled setpoints based on Zone Group mode

4. Local override: When thermostat override buttons are depressed, the request for Occupied Mode operation shall be sent up to the Zone Group control for 60 minutes. (This will cause all zones in the Zone Group to operate in Occupied Mode to ensure that the system has adequate load to operate stably.)

5. Control Loops

a. Two separate control loops shall operate to maintain space temperature at setpoint, the Cooling Loop and the Heating Loop. Both loops shall be continuously active.

b. The Cooling Loop shall maintain the space temperature at the active cooling setpoint. The output of the loop shall be a virtual point ranging from 0% (no cooling) to 100% (full cooling).
c. The Heating Loop shall maintain the space temperature at the active heating setpoint. The output of the loop shall be a virtual point ranging from 0% (no heating) to 100% (full heating).

d. Loops shall be use proportional + integral logic or fuzzy logic. Proportional-only control is not acceptable, although the integral gain shall be small relative to the proportional gain. P and I gains shall be adjustable from the Operator Workstation.

e. See other sections for how the outputs from these loops are used.

6. Zone Modes

a. Heating Mode: when the output of the space heating control loop is less than zero.

b. Cooling Mode: when the output of the space cooling control loop is greater than zero and the output of the heating loop is equal to zero.

c. Deadband Mode: when not in either the Heating or Cooling Mode.

7. Alarms

a. Zone temperature alarms

1) If the zone is 3°F above cooling or below heating setpoint for 10 minutes, generate Level 3 alarm.

2) If the zone is 5°F above cooling or below heating setpoint for 10 minutes, generate Level 2 alarm.

3) Suppress zone temperature alarms as follows:

   a) After zone setpoint is changed for a period of 10 minutes per degree of difference between the zone temperature at the time of the change and the new setpoint. This suppression period applies any time that the zone setpoint is changed.

   b) While Zone Group is in Warm-up or Cool-down Modes.

   c) For zones with window switches, when any window is detected open.

   d) For zones with an Importance multiplier (see Trim & Respond sequences above) of zero.

b. For zones with CO2 sensors

1) If the CO2 concentration is less than 300 ppm, or the zone is in unoccupied mode for more than 2 hours and zone CO2 concentration exceeds 600 ppm, generate a Level 4 alarm, indicating sensor may be out of calibration.
2) If the CO₂ concentration exceeds setpoint plus 10% for more than 10 minutes generate a Level 3 alarm.

### 4.03 VAV REHEAT TERMINALS

A. See Generic Thermal Zones (4.02B.2) for setpoints, loops, control modes, alarms, etc

B. See ASHRAE Guideline 36 section 3.1B.3 for zone minimum airflow setpoints Vmin, zone maximum cooling airflow setpoint Vcool-max, zone maximum heating design airflow setpoint Vheat-max, and the maximum discharge air temperature rise above heating setpoint, MaxΔT

C. Active maximum and minimum setpoints shall vary depending on the Mode of the Zone Group the zone is a part of:

<table>
<thead>
<tr>
<th>Setpoint</th>
<th>Occupied</th>
<th>Cool-down</th>
<th>Setup</th>
<th>Warmup</th>
<th>Setback</th>
<th>Unoccupied</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooling maximum</td>
<td>Vcool-max</td>
<td>Vcool-max</td>
<td>Vcool-max</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Cooling minimum</td>
<td>Vmin*</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Minimum</td>
<td>Vmin*</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Heating minimum</td>
<td>Vmin*</td>
<td>0</td>
<td>0</td>
<td>Vheat-max</td>
<td>Vheat-max</td>
<td>0</td>
</tr>
<tr>
<td>Heating maximum</td>
<td>Max(Vheat-max, Vmin*)</td>
<td>Vheat-max</td>
<td>0</td>
<td>Vcool-max</td>
<td>Vcool-max</td>
<td>0</td>
</tr>
</tbody>
</table>
D. Control logic is depicted schematically in the figure below and described in the following sections. Relative levels of various setpoints are depicted for Occupied Mode operation.
1. When the Zone State is Cooling, the Cooling Loop output shall be mapped to the airflow setpoint from the cooling minimum to the cooling maximum airflow setpoints. Hot water valve is closed unless the discharge air temperature is below the minimum setpoint [see E.4 below].
   a. If supply air temperature from the air handler is greater than room temperature, cooling supply airflow setpoint shall be no higher than the minimum.

2. When the Zone State is Deadband, the active airflow setpoint shall be the minimum airflow setpoint. Hot water valve is closed unless the discharge air temperature is below the minimum setpoint [see E.4 below].

3. When the Zone State is Heating, the Heating Loop shall maintain space temperature at the heating setpoint as follows:
   a. From 0-50%, the Heating Loop output shall reset the discharge temperature setpoint from the current AHU SAT setpoint to a maximum of MaxΔT above space temperature setpoint. The airflow setpoint shall be the heating minimum.
   b. From 51%-100%, if the discharge air temperature is greater than room temperature plus 2.8°C (5°F), the Heating Loop output shall reset the airflow setpoint from the heating minimum airflow setpoint to the heating maximum airflow setpoint.
   c. The hot water valve shall be modulated to maintain the discharge temperature at setpoint. (Directly controlling heating off the zone temperature control loop is not acceptable.)
      1) When the airflow setpoint is pulse width modulated per 5.2C, the hot water valve shall be shut and PID loop disabled with output set to 0 during closed periods.

4. In Occupied Mode, the hot water valve (or modulating electric heating coil) shall be modulated to maintain a discharge air temperature no lower than 10°C (50°F).

E. Alarms

1. Low airflow
   a. If the measured airflow is less than 70% of setpoint for 5 minutes while setpoint is greater than zero, generate a Level 3 alarm.
   b. If the measured airflow is less than 50% of setpoint for 5 minutes while setpoint is greater than zero, generate a Level 2 alarm.
   c. If a zone has an Importance multiplier of 0 [4.02 A.14.b] for its static pressure reset Trim & Respond control loop, low airflow alarms shall be suppressed for that zone.
2. Low discharge air temperature
   a. If boiler plant is proven on and the discharge air temperature is 8.3°C (15°F) less than setpoint for 10 minutes, generate a Level 3 alarm.
   b. If boiler plant is proven on and the discharge air temperature is 17°C (30°F) less than setpoint for 10 minutes, generate a Level 2 alarm.
   c. If a zone has an Importance multiplier of 0 [see 4.02A.14b)] for its Hot Water reset Trim & Respond control loop, low discharge air temperature alarms shall be suppressed for that zone.

3. Airflow sensor calibration. If the fan serving the zone has been off for 10 minutes and airflow sensor reading is above 5% of the cooling maximum airflow setpoint, generate a Level 3 alarm.

4. Leaking damper. If the damper position is 0% for 10 minutes and airflow sensor reading is above 24 lps (50 cfm) while the fan serving the zone is proven on, generate a Level 4 alarm.

5. Leaking valve. If the valve position is 0% for 15 minutes, discharge air temperature is above AHU SAT by 2.8°C (5°F), and the fan serving the zone is proven on, generate a Level 4 alarm.

F. Testing/Commissioning Overrides: Provide software switches that interlock to a system level point to

1. Force zone airflow setpoint to zero
2. Force zone airflow setpoint to Vcool-max
3. Force zone airflow setpoint to Vmin
4. Force zone airflow setpoint to Vheat-max
5. Force damper full closed/open
6. Force heating to off/closed
7. Reset request-hours accumulator point to zero (provide one point for each reset type listed below).

G. System Requests

1. Cooling SAT Reset Requests
   a. If the zone temperature exceeds the zone’s cooling setpoint by 2.8°C (5°F) for 2 minutes and after suppression period due to setpoint change per 5.1T, send 3 Requests,
b. Else if the zone temperature exceeds the zone’s cooling setpoint by 1.7°C (3°F) for 2 minutes and after suppression period due to setpoint change per 5.1T, send 2 Requests,

c. Else if the Cooling Loop is greater than 95%, send 1 Request until the Cooling Loop is less than 85%,

d. Else if the Cooling Loop is less than 95%, send 0 Requests

2. Static Pressure Reset Requests

a. If the measured airflow is less than 50% of setpoint while setpoint is greater than zero for 1 minute, send 3 Requests,

b. Else if the measured airflow is less than 70% of setpoint while setpoint is greater than zero for 1 minute, send 2 Requests,

c. Else if the damper position is greater than 95%, send 1 Request until the damper position is less than 85%,

d. Else if the damper position is less than 95%, send 0 Requests

3. If there is a hot water coil, Hot Water Reset Requests

a. If the discharge air temperature is 17°C (30°F) less than setpoint for 5 minutes, send 3 Requests,

b. Else if the discharge air temperature is 8.3°C (15°F) less than setpoint for 5 minutes, send 2 Requests,

c. Else if HW valve position is greater than 95%, send 1 Request until the HW valve position is less than 85%,

d. Else if the HW valve position is less than 95%, send 0 Requests

4. If there is a hot water coil and a boiler plant, Boiler Plant Requests. Send the boiler plant that serves the zone a Boiler Plant Request as follows:

a. If the HW valve position is greater than 95%, send 1 Request until the HW valve position is less than 10%

b. Else if the HW valve position is less than 95%, send 0 Requests.

4.04 PACKAGED ROOFTOP AC UNIT OR HEAT PUMP

A. The BAS shall start and stop the AC unit based on a time schedule as directed by the College. Time schedule shall include daily start/stop occupied and unoccupied mode, weekend and holidays.
B. Once started the AC unit shall operate under their own built-in control to stage the heating and cooling system to maintain the room temperature set point. Currently set the rooftop temperature at 68°F for heating and 78°F for cooling. Once energized the supply fan shall be programmed to run continuously during the occupied hours.

C. The AC unit shall interface with the BAS via BACnet communication. Provide list of available points to the College for review and direction of points implementation to the BAS system. At the very least provide the following:

1. Room temperature.
2. Room temperature set point and reset
3. Unit run time
4. Heating or cooling mode
5. Gas or electric heating staging
6. Cooling/compressor staging
7. Summary alarm.
8. Schedule
9. Electrical information such as
   a. Running load amps or KW
   b. Energy consumption (KwH)
10. Fan status
11. Economizer damper mode
12. Condenser fan modulation and speed (where applicable).

D. Maintenance Notification: Provide maintenance notifications. Use BACnet points if available, otherwise use routine based on the manufacturer’s recommendations or as directed by the College.

4.05 CONSTANT VOLUME CHILLED WATER PLANT (AIR COOLED CHILLER)

A. The BAS shall start and stop the chilled water system based on a preset schedule as determined by the College.

B. Once system is energized, start the circulating pump. If the lead pump fails to operate after 2 minutes have elapsed from “pump on” command, the BAS shall start the lag pump. Once flow is proven, the chiller shall start to operate in automatic under its own control to maintain the chilled water temperature set point.
C. Reset the chilled water temperature set point based on outside air temperature.

D. Alternate the pump lead/lag operation based on equal run time.

E. Lock out the chilled water plant when the outside air temperature is below 60°F (adjustable).

F. Monitor and alarm the following:
   1. Monitor:
      a. Chiller and pump status
      b. CHWS/R temperature
      c. O.A. temperature
   2. Alarm:
      a. Pump failure
      b. Chiller summary alarm
      c. High CHWS temperature (+5 degrees over the set point)

G. Maintenance Notification: Provide maintenance notification. Use BACnet points if available, otherwise use run time based on the manufacturer's recommendation or as directed by the College.

H. The Chiller shall interface with the BAS via BACnet (or Modbus if BACnet is not available) Communications. Provide list of points to the College for review and direction of points implementation to the BAS system at the very least, provide the following:
   1. CHWS/R Temperature
   2. CHWS Temperature setpoint
   3. Run time
   4. Summary Alarm
   5. Running Amp or KW
   6. Energy Consumption (Kwh)
   7. Compressor staging
   8. Condenser fan status
   9. Efficiency (KW/Ton)
4.06 VARIABLE VOLUME CHILLED WATER PLANT (AIR COOLED CHILLER)

A. The BAS shall start and stop the chilled water system based on a preset schedule as determined by the College.

B. Once system is energized, start the chilled water circulating pump. Once flow is proven, the chiller shall start to operate in automatic under its own control to maintain chilled water temperature set point.

C. CCC PAC Building #39:
   1. Reset the chilled water temperature setpoint based on outside air temperature.
   2. The chilled water pump shall modulate to maintain a preset pipe differential pressure as determined by the balancer.

D. DVC Kinesiology Building #11:
   1. Pump Modulation:
      a. When the pumping system is enabled, the DP control loop is enabled. The loop shall be a reverse-acting loop maintaining the differential pressure (DP) sensor at setpoint. The minimum pump speed shall be limited to the allowable minimum flow through the chiller plus 10%
2. CHW Temperature and DP setpoint reset:
   a. Chilled water supply temperature setpoint and pump differential static pressure setpoint shall be reset based on the figure below and the value CHW Plant Reset determined as described below. $\text{DP}_{\text{max}}$ shall be determined under Div 23 Testing, Adjusting and Balancing. $T_{\text{min}}$ is the design chilled water temperature as scheduled on Drawings:
b. CHW Plant Reset shall be reset using Trim & Respond logic (see Paragraph 4.02A.7) based on chilled water pump status with the following parameters:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>SP0</td>
<td>0%</td>
</tr>
<tr>
<td>SPmin</td>
<td>0%</td>
</tr>
<tr>
<td>SPmax</td>
<td>100%</td>
</tr>
<tr>
<td>Td</td>
<td>15 minutes</td>
</tr>
<tr>
<td>T</td>
<td>5 minutes</td>
</tr>
<tr>
<td>I</td>
<td>2</td>
</tr>
<tr>
<td>R</td>
<td>Cooling CHWST Reset Requests</td>
</tr>
<tr>
<td>SPtrim</td>
<td>-2%</td>
</tr>
<tr>
<td>SPres</td>
<td>+3%</td>
</tr>
<tr>
<td>SPres-max</td>
<td>+7%</td>
</tr>
</tbody>
</table>

E. Chilled water plant reset logic shall be disabled and valve fixed at the last valve for 15 minutes after the plant stages up and down.

F. Lock out the chilled water plant when outside air is below 60°F (adjustable).

G. Monitor and alarm the following:

1. **Monitor:**
   a. Chiller status
   b. Chilled water pump status
   c. CHWS/R Temperature
   d. CHWP speed
   e. Outside air temperature

2. **Alarm:**
   a. Chiller summary alarm
   b. Pump failure
   c. High chilled water supply temperature setpoint (+5 degrees over the setpoint).
H. Maintenance Notification: Provide maintenance notification. Use BACnet points if available, otherwise use run time based on the manufacturer’s recommendation or as directed by the College.

I. The Chiller shall interface with the BAS via BACnet (or Modbus if BACnet is not available) Communications. Provide list of points to the College for review and direction of points implementation to the BAS system at the very least, provide the following:

1. CHWS/R Temperature
2. CHWS Temperature setpoint
3. Run time
4. Summary Alarm
5. Running Amp or KW
6. Energy Consumption (KwH)
7. Compressor staging
8. Condenser fan status
9. Efficiency (KW/Ton)
10. Demand (Ton)
11. Load (Ton hours)

J. The VFD shall interface with the BAS via BACnet communications. Provide BACnet points list to the College for review and direction of points implementations to the BAS. At the very least provide the following:

1. Run time
2. Speed
3. Running frequency
4. Running Amp
5. Energy consumptions (KwH)
6. Summary Alarms
7. Hand, OFF or Auto
4.07 CHILLED WATER PLANT (WATER COOLED CHILLER)

A. The BAS shall start and stop the chilled water plant based on a preset schedule as determined by the College.

B. Chiller plant shall be locked out when outside air temperature is below 60°F (adjustable).

C. Once the chilled water plant is energized, start the lead chilled water and condenser water pumps. Upon proof of flow, the chiller shall be energized and operate automatically to maintain the chilled water supply temperature setpoint. See paragraph 3.15A.10 for pump lead lag operation.

D. Reset the chilled water temperature setpoint based on outside air temperature.

E. The VFD driven chilled water pump shall modulate the pump speed via a PID loop to maintain the chilled water pipe differential set point as determined by the balancer.

F. Cooling Tower:
   1. On initial start up the condenser water by-pass valve shall be on full by-pass, and gradually modulate open until the condenser water temperature set point is reached.
   2. The cooling tower fan shall modulate to maintain the condenser tower water temperature setpoint.

G. Apply the chiller and chiller tower performance map to determine the most energy efficient plant performance combination as a function of condenser water temperature and condenser water flow with respect to the outside air condition.

H. The BAS shall perform calculations on the cooling demand (ton) and load (ton hours) based on the chilled water and CHWS/R temperature reading. Calculate tons based on the following formula:

   \[ \text{Tons} = \frac{\text{GMP} \times (\text{Tin} - \text{Tut})}{24} \]

I. Monitoring and Alarm
   1. Monitor:
      a. Chiller status
      b. Pump status
      c. Cooling tower status
      d. Chilled water flow
e. Condenser water flow
f. CHWS/R temperature
g. CWS/R temperature
h. Outside air temperature
i. Outside air relative humidity
j. Side stream separator status
k. Refrigerant monitor status and alarm

2. Alarm
a. Chiller summary alarm
b. Cooling tower fan failure
c. Condenser water supply temperature
d. High CHW supply temperature
e. Pump failure
f. Side stream separator status alarm
g. Refrigerant alarm.

J. Side Stream Separator:
1. The BAS shall start the cooling tower side stream separator operation on a predetermined interval and duration as determined by the water treatment vendor.

2. Provide status alarm when the side stream separator pump fails to operate.

K. Refrigerant leak monitoring system
1. Continuously monitor for oxygen level and refrigerant leak in the chiller plant.

L. Maintenance Notification: Provide maintenance notification. Use BACnet points if available, otherwise use run time based on the manufacturer’s recommendation or as directed by the College.

M. The Chiller shall interface with the BAS via BACnet (or Modbus if BACnet is not available) Communications. Provide list of points to the College for review and direction of points implementation to the BAS system at the very least, provide the following:
1. CHWS/R Temperature
2. CHWS Temperature setpoint
3. Run time
4. Summary Alarm
5. Running Amp or KW
6. Energy Consumption (KwH)
7. Compressor staging
8. Condenser fan status
9. Efficiency (KW/Ton)
10. Demand (Ton)
11. Load (Ton hours)

4.08 HEATING HOT WATER PLANT

A. The BAS shall start and stop the heating hot water plant based on a time schedule as directed by the College. Time schedule include daily start/stop occupied and unoccupied hours, weekends, and holidays.

B. Once energized, the BAS shall start the hot water pump. Upon proof of flow, the boiler shall be energized and operate automatically under its own control to maintain the preset hot water temperature.

C. Reset the hot water supply temperature based on outside air temperature.

D. Monitor and alarm the following:

1. Monitor:
   a. Boiler status
   b. Pump status
   c. HHWS/R Temperature

2. Alarm:
   a. Boiler status alarm
   b. Pump failure
c. Low hot water temperature (-5°F below setpoint)

E. Maintenance Notification: Provide maintenance notification. Use BACnet points if available, otherwise use run time based on the manufacturer's recommendation or as directed by the College.

F. The boiler shall interface with the BAS via Modbus communications. Provide list of points to the College for review and direction of points implementation to the BAS system. At the very least provide the following:

1. Firing rate/stage
2. Run time
3. HHWS set point
4. Gas consumption (Thermos)
5. Electrical:
   a. Amp
   b. Consumption (KwH)
6. Status alarm

G. The VFD shall interface with the BAS via BACnet communications. Provide BACnet points list to the College for review and direction of points implementation to the BAS. At the very least provide the following:

1. Run time
2. Speed
3. Running frequency
4. Running Amp
5. Energy consumptions (KwH)
6. Summary Alarms
7. Hand, OFF or Auto

4.09 DVC – KINESIOLOGY BUILDING #11-AIR HANDLING UNIT CONTROL

A. The air handling unit shall start and stop based on the preset schedule as determined by the College. Schedule shall include weekday start/stop occupied and unoccupied, weekend, and holidays.
B. When the unit is “off” the outside air damper is fully closed and the return air is fully open.

C. Warm up or cool down mode: During the initial startup, the air handling unit shall be in a warm up or cool down mode. During this mode, the economizer damper shall be in a 100% return air mode. Once the room temperature reaches 5 degrees (adjustable) above or below the set point, the AHU shall operate under normal mode. The economizer damper shall start to modulate open and maintain the space CO2 level below 1000 ppm (set minimum outside air at 10%). Send alarm when the outside air damper is 85% open and the CO2 level is still above 1000 ppm.

D. During the occupied mode, the BAS shall sequence the economizer damper, heating and cooling coil control valves to maintain the room temperature set point at 75°F for cooling and 68°F for heating. There shall not be an overlap between the operation of the heating and cooling coil control valves. The sequence shall be as follow:

1. Minimum and maximum supply air temperature setpoints shall be as follows:
   a. Cool_SAT and Heat_SAT shall be per 3.1F.1
   b. The Deadband values of SATsp and SATsp-C shall be the reading of the zone heating setpoint and the zone cooling setpoint but shall be no lower than 21°C (70°F) and no higher than 24°C (75°F).

2. When the supply fan is proven on, fan speed and supply air temperature setpoints are controlled as shown in the following diagrams and text. The points of transition along the x-axis shown and described below are representative. Separate gains shall be provided for each section of the control map (hot water, economizer, chilled water), that are determined by the Design Builder to provide stable control.

![Diagram showing supply temperature setpoints and deadbands for heating and cooling loops.](attachment:diagram.png)
a. For a Heating Loop signal of 100% - 50%, SATsp is Heat_SAT.

b. For a Heating Loop signal of 50% - 0%, SATsp is reset from Max_SAT to the Deadband value.

c. In Deadband, SATsp is the Deadband value.

d. For a Cooling Loop signal of 0% - 25%, SATsp is reset from the Deadband value to Cool_SAT minus 1.1°C (2°F), while SATsp-C is the Deadband value.

e. For a Cooling Loop signal of 25% - 50%, SATsp and SATsp-C are unchanged.

f. For a Cooling Loop signal of 50% - 75%, SATsp remains at Cool_SAT minus 1.1°C (2°F), SATsp-C is reset from the Deadband value to Cool_SAT.

g. For a Cooling Loop signal of 75% - 100%, SATsp and SATsp-C are unchanged.

3. Supply Air Temperature Control

a. There are two supply air temperature setpoints, SATsp and SATsp-C. Each setpoint is maintained by a separate control loop but both loops use the same supply air temperature sensor.

b. The control loop for SATsp is enabled when the supply air fan is proven on and disabled and set to Neutral otherwise.

1) Supply air temperature shall be controlled to SATsp by a control loop whose output is mapped to sequence the hot water valve and economizer dampers as shown in the diagram below. Outdoor air damper minimum (MinOA-P) and maximum (MaxOA-P) positions are limited for economizer lockout and to maintain minimum outdoor airflow rate as described in paragraphs 4 and 5.

2) The points of transition along the x-axis shown below are representative. Separate gains shall be provided for each section of the control map (hot water, economizer, chilled water), that are determined by the Design Builder to provide stable control. Alternatively, Design Builder shall adjust the precise value of the x-axis thresholds shown in the figure to provide stable control.
c. The control loop for SATsp-C is enabled when the supply fan is proven on and the Zone State is Cooling and disabled and set to Neutral otherwise. When enabled, supply air temperature shall be controlled to SATsp-C by modulating the CHW valve.

4. Minimum Outdoor Air Control

a. See 5.2B for calculation of zone minimum outdoor airflow setpoint.

b. Outdoor Air Damper Control

1) See 3.2B.2 for minimum damper position setpoints.

2) If MinOAsp is zero, MinOA-P shall be zero (i.e., outdoor air damper fully closed).

5. Economizer Lockout

a. The normal sequencing of the economizer dampers (above) shall be disabled in accordance with 5.1Q.

b. Once the economizer is disabled, it shall not be re-enabled within 10 minutes, and vice versa.
c. When economizer is enabled, MaxOA-P = 100%. When economizer is disabled set MaxOA-P equal to MinOA-P. See Supply Air Temperature Control (part 3) and Minimum Outdoor Air Control (part 4) for outdoor air damper minimum setpoint.

E. Occupancy Override:
1. During the operating hours, if the room is unoccupied as sensed by the room occupancy sensors, stop the air handling unit and increase the room temperature setpoint dead band to -5 degrees F below the heating setpoint and +5 degrees above the cooling setpoint.
2. If the room is continuously unoccupied for one hour (adjustable), stop the air handler.
3. When the room temperature drops 5 degrees below or rises 5 degrees above the unoccupied room temperature setpoint, the BAS shall start the AHU to maintain the unoccupied room temperature. Once the room temperature is within the 2 degrees of dead band boundaries, turn off the AC unit. Limit the AHU cycling to 2 times/hour.
4. When the room is occupied, the BAS shall restart the AHU to run at occupied mode.
5. Provide an adjustable time delay between occupied and unoccupied mode to minimize rapid transition between modes:
   a. From occupied to unoccupied: 10 minutes
   b. From unoccupied to occupied: 5 minutes

F. Filter Differential: The BAS shall continuously monitor the filter differential pressure drop and alarm when the filter pressure drop exceeds 0.75 in w.c. (adjustable).

G. Standard Alarms
1. Maintenance interval alarm when fan has operated for more than 1,500 hours: Level 4. Reset interval counter when alarm is acknowledged.
2. Fan alarm is indicated by the status being different from the command for a period of 15 seconds.
   a. Commanded on, status off: Level 2
   b. Commanded off, status on: Level 4
4.10 DVC – PERFORMING ARTS CENTER BUILDING #23 AIR HANDLING UNITS AH-4, 5 7 AND 8 CONTROL (SINGLE ZONE VAV AHU)

A. The air handling unit shall start and stop based on the preset schedule as determined by the College. Schedule shall include weekday start/stop occupied and unoccupied, weekends, and holidays.

B. When the unit is “off”, the outside air damper is fully closed and the return air damper is fully open.

C. Warm up or cool down mode: During the initial startup, the air handling unit shall be in a warm up or cool down mode. During this mode, the economizer damper shall be in a 100% return air mode. Once the room temperature reaches 5 degrees (adjustable) above or below the set point, the AHU shall operate under normal mode. The economizer damper shall start to modulate open and maintain the space CO2 level below 1000 ppm. Send alarm when the outside air damper is 85% open and the CO2 level is still above 1000 ppm.

D. In the occupied mode the BAS shall modulate the supply fan and sequence the economizer damper, heating coil control valve and chilled water control valve to maintain the room temperature setpoint at 75°F for cooling and 68°F for heating.

1. See Generic Thermal Zones for setpoints, loops, control modes, alarms, etc.

2. Supply Fan Speed Control and Supply Air Temperature Setpoint Reset

   a. The supply fan shall run whenever the unit is in any mode other than Unoccupied Mode.

   b. Provide a ramp function to prevent changes in fan speed of more than 10% per minute.

   c. Minimum, medium, and maximum fan speeds shall be as follows:

      1) Maximum cooling fan speed (MaxCoolSpeed), maximum heating fan speed (MaxHeatSpeed), and minimum fan speed (MinSpeed) setpoints shall be per ASHRAE Guideline 36 part 3.2B.1.

      2) Medium fan speed (MedSpeed) shall be reset linearly based on outdoor air temperature between the following endpoints.

         a) When the outdoor air temperature equals the zone temperature +0.56°C (1°F), Medspeed shall be MinSpeed.

         b) When the outdoor air temperature is 5.6°C (10°F) below the zone temperature, Medspeed shall be equal to MaxCoolSpeed.

   d. Minimum and maximum supply air temperature setpoints shall be as follows:
1) Cool SAT and Heat SAT shall be determined based on the heating and cooling coil selection design temperatures.

2) The Deadband values of SATsp and SATsp-C shall be the average of the zone heating setpoint and the zone cooling setpoint but shall be no lower than 21°C (70°F) and no higher than 24°C (75°F).

e. When the supply fan is proven on, fan speed and supply air temperature setpoints are controlled as shown in the following diagrams and text. The points of transition along the x-axis shown and described below are representative. Separate gains shall be provided for each section of the control map (hot water, economizer, chilled water), that are determined by the Design Builder to provide stable control.

f. Alternatively, Design Builder shall adjust the precise value of the x axis thresholds shown in the figure to provide stable control.

Below, the same diagram is separated into two diagrams for clarity and to illustrate the relative setpoints. However, both fan speed and supply air temperature setpoints are reset simultaneously and by the same signal – the value of the Heating Loop or Cooling Loop.
1) For a Heating Loop signal of 100% - 50%, fan speed is reset from MaxHeatSpeed to MinSpeed.

2) For a Heating Loop signal of 50% - 0%, fan speed setpoint is MinSpeed.

3) In Deadband, fan speed setpoint is MinSpeed.

4) For a Cooling Loop signal of 0% - 25%, fan speed is MinSpeed.

5) For a Cooling Loop signal of 25% - 50%, fan speed is reset from MinSpeed to MedSpeed.

6) For a Cooling Loop signal of 50% - 75%, fan speed is MedSpeed.

7) For a Cooling Loop signal of 75% - 100%, fan speed is reset from MedSpeed to MaxCoolSpeed.
3. Supply Air Temperature Control
   
a. There are two supply air temperature setpoints, SATsp and SATsp-C. Each setpoint is maintained by a separate control loop but both loops use the same supply air temperature sensor.

b. The control loop for SATsp is enabled when the supply air fan is proven on and disabled and set to Neutral otherwise.

8) For a Heating Loop signal of 100% - 50%, SATsp is Heat_SAT.

9) For a Heating Loop signal of 50% - 0%, SATsp is reset from Max_SAT to the Deadband value.

10) In Deadband, SATsp is the Deadband value.

11) For a Cooling Loop signal of 0% - 25%, SATsp is reset from the Deadband value to Cool_SAT minus 1.1°C (2°F), while SATsp-C is the Deadband value.

12) For a Cooling Loop signal of 25% - 50%, SATsp and SATsp-C are unchanged.

13) For a Cooling Loop signal of 50% - 75%, SATsp remains at Cool_SAT minus 1.1°C (2°F), SATsp-C is reset from the Deadband value to Cool_SAT.

14) For a Cooling Loop signal of 75% - 100%, SATsp and SATsp-C are unchanged.
1) Supply air temperature shall be controlled to SATsp by a control loop whose output is mapped to sequence the hot water valve or modulating electric heating coil (if applicable) and economizer dampers as shown in the diagram below. Outdoor air damper minimum (MinOA-P) and maximum (MaxOA-P) positions are limited for economizer lockout and to maintain minimum outdoor airflow rate as described in paragraph 4.11 D.4.

2) The points of transition along the x-axis shown below are representative. Separate gains shall be provided for each section of the control map (hot water, economizer, chilled water), that are determined by the Design Builder to provide stable control. Alternatively, Design Builder shall adjust the precise value of the x-axis thresholds shown in the figure to provide stable control.

![Diagram of SATsp Control Loop]

- Return Air Damper Position
- Outdoor Air Damper Position
- HW Valve/Coil (if applicable)
- MinOA-P
- MaxOA-P

100% SATsp Control Loop

0%

The control loop for SATsp-C is enabled when the supply fan is proven on and the Zone State is Cooling and disabled and set to Neutral otherwise. When enabled, supply air temperature shall be controlled to SATsp-C by modulating the CHW valve.
4. Minimum Outdoor Air Control
   
a. See 5.2B for calculation of zone minimum outdoor airflow setpoint

b. Outdoor Air Damper Control
   
1) See ASHRAE Guideline 36 part 3.2B.2 for minimum damper position setpoints.

2) At least once per minute while the zone is in Occupied Mode, the BAS shall calculate MinPos* as a linear interpolation between MinPosMin and MinPosMax based on the current fan speed.

3) At least once per minute while the zone is in Occupied Mode, the BAS shall calculate DesPos* as a linear interpolation between DesPosMin and DesPosMax based on the current fan speed.

4) If MinOAsp is zero, MinOA-P shall be zero (i.e., outdoor air damper fully closed).

5) If MinOAsp is non-zero, then the outdoor air damper minimum position MinOA-P shall be the value between MinPos* and DesPos* that is proportional to the value of MinOAsp between MinOA and DesOA. The following diagram is an illustrative example (points are chosen arbitrarily and are not meant to be representative):
5. Economizer Lockout
   a. The normal sequencing of the economizer dampers (above) shall be disabled in accordance with 5.1Q.
   b. Once the economizer is disabled, it shall not be re-enabled within 10 minutes, and vice versa.
   c. When economizer is enabled, MaxOA-P = 100%. When economizer is disabled set MaxOA-P equal to MinOA-P. See Supply Air Temperature Control (5.16C) and Minimum Outdoor Air Control (5.16D) for outdoor air damper minimum setpoint.

6. Standard Alarms
   a. Maintenance interval alarm when fan has operated for more than 1,500 hours: Level 4. Reset interval counter when alarm is acknowledged.
   b. Fan alarm is indicated by the status being different from the command for a period of 15 seconds.
      1) Commanded on, status off: Level 2.
      2) Commanded off, status on: Level 4

E. Filter pressure drop: BAS shall continuously monitor the filter differential pressure drop and alarm when the pressure drop exceed the alarm set point at maximum design air volume.

4.11 DVC – PERFORMING ARTS CENTER BUILDING #23 – AHU-2, AND 6 CONTROL

A. The air handling unit shall start and stop based on the preset schedule as determine by the College. Schedule shall include weekday start/stop occupied and unoccupied, weekend, and holidays.

B. Once started, the AHU shall sequence the heating coil and chilled water control valves to maintain the room temperature set point of 75°F for cooling and 68°F for heating. The sequence shall be as follow:

1. Minimum and maximum supply air temperature setpoints shall be as follows:
   a. Cool_SAT and Heat_SAT shall be per 3.1F.1.
   b. The Deadband values of SATsp and SATsp-C shall be the average of the zone heating setpoint and the zone cooling setpoint but shall be no lower than 21°C (70°F) and no higher than 24°C (75°F).

2. When the supply fan is proven on, and supply air temperature setpoints are controlled as shown in the following diagrams and text. The points of transition along the x-axis shown and described below are representative. Separate gains
shall be provided for each section of the control map (hot water, chilled water),
that are determined by the Design Builder to provide stable control. Alternatively,
Design Builder shall adjust precise value of the X-axis thresholds shown in the
figure to provide stable control.

3. Supply Air Temperature Control

a. For a Heating Loop signal of 100% - 50%, SATsp is Heat_SAT.

b. For a Heating Loop signal of 50% - 0%, SATsp is reset from Max_SAT to
   the Deadband value.

c. In Deadband, SATsp is the Deadband value.

d. For a Cooling Loop signal of 0% - 25%, SATsp is reset from the
   Deadband value to Cool_SAT minus 1.1°C (2°F), while SATsp-C is the
   Deadband value.

e. For a Cooling Loop signal of 25% - 50%, SATsp and SATsp-C are
   unchanged.

f. For a Cooling Loop signal of 50% - 75%, SATsp remains at Cool_SAT
   minus 1.1°C (2°F), SATsp-C is reset from the Deadband value to
   Cool_SAT.

g. For a Cooling Loop signal of 75% - 100%, SATsp and SATsp-C are
   unchanged.
a. There are two supply air temperature setpoints, SATsp and SATsp-C. Each setpoint is maintained by a separate control loop but both loops use the same supply air temperature sensor.

b. The control loop for SATsp is enabled when the supply air fan is proven on and disabled and set to Neutral otherwise.

1) Supply air temperature shall be controlled to SATsp by a control loop whose output is mapped to sequence the hot water.

2) The points of transition along the x-axis shown below are representative. Separate gains shall be provided for each section of the control map (hot water, chilled water), that are determined by the Design Builder to provide stable control. Alternatively, Design Builder shall adjust the precise value of the x-axis thresholds shown in the figure to provide stable control.

3) The control loop for SATsp-C is enabled when the supply fan is proven on and the Zone State is Cooling and disabled and set to Neutral otherwise. When enabled, supply air temperature shall be controlled to SATsp-C by modulating the CHW valve.

C. Occupancy Override:

1. During the operating hours, if the room is unoccupied as sensed by the room occupancy sensors, stop the air handling unit and increase the room temperature
setpoint dead band to -5 degrees F below the heating setpoint and +5 degrees above the cooling setpoint.

2. When the room temperature drops 5 degrees below or rises 5 degrees above the unoccupied room temperature setpoint, the BAS shall start the AHU to maintain the unoccupied room temperature. Once the room temperature is within the 2 degrees of dead band boundaries, turn off the AC unit. Limit the AHU cycling to 2 times/hour.

3. When the room is occupied, the BAS shall restart the AHU to run at occupied mode.

D. Filter Differential: The BAS shall continuously monitor the filter differential pressure drop and alarm when the filter pressure drop exceeds 0.75 in. w.c. (adjustable).

E. Standard Alarms

1. Maintenance interval alarm when fan has operated for more than 1,500 hours: Level 4. Reset interval counter when alarm is acknowledged.

2. Fan alarm is indicated by the status being different from the command for a period of 15 seconds.
   a. Commanded on, status off: Level 2.
   b. Commanded off, status on: Level 4

F. Sequence of operation for AHU-3 is similar, except AHU-3 has Economizer dampers. See part 4.10 for economizer damper control sequence

4.12 DVC – PERFORMING ARTS CENTER BUILDING #23 – AHU-1 CONTROL

A. The air handling unit shall start and stop based on the preset schedule as determined by the College. Schedule shall include weekday start/stop occupied and unoccupied, weekends, and holidays.

B. When the unit is "off", the outside air damper is fully closed and the return air damper is fully open.

C. Warm up or cool down mode: During the initial startup, the air handling unit shall be in a warm up or cool down mode. During this mode, the economizer damper shall be in a 100% return air mode. Once the room temperature reaches 5 degrees (adjustable) above or below the set point, the AHU shall operate under normal mode.

D. In the occupied mode the BAS shall modulate the supply fan and sequence the economizer damper, heating coil control valve and chilled water control valve to maintain the room temperature setpoint at 75°F for cooling and 68°F for heating.

1. See Generic Thermal Zones for setpoints, loops, control modes, alarms, etc.
2. Supply Fan Speed Control and Supply Air Temperature Setpoint Reset

a. The supply fan shall run whenever the unit is in any mode other than Unoccupied Mode.

b. Provide a ramp function to prevent changes in fan speed of more than 10% per minute.

c. Minimum, medium, and maximum fan speeds shall be as follows:

1) Maximum cooling fan speed (MaxCoolSpeed), maximum heating fan speed (MaxHeatSpeed), and minimum fan speed (MinSpeed) setpoints shall be per ASHRAE Guideline 36 part 3.2B.1.

2) Medium fan speed (MedSpeed) shall be reset linearly based on outdoor air temperature between the following endpoints.
   c) When the outdoor air temperature equals the zone temperature +0.56°C (1°F), Medspeed shall be MinSpeed.
   d) When the outdoor air temperature is 5.6°C (10°F) below the zone temperature, Medspeed shall be equal to MaxCoolSpeed.

d. Minimum and maximum supply air temperature setpoints shall be as follows:

1) Cool SAT and Heat SAT shall be determined based on the heating and cooling coil selection design temperatures.

2) The Deadband values of SATsp and SATsp-C shall be the average of the zone heating setpoint and the zone cooling setpoint but shall be no lower than 21°C (70°F) and no higher than 24°C (75°F).

e. When the supply fan is proven on, fan speed and supply air temperature setpoints are controlled as shown in the following diagrams and text. The points of transition along the x-axis shown and described below are representative. Separate gains shall be provided for each section of the control map (hot water, economizer, chilled water), that are determined by the Design Builder to provide stable control.

f. Alternatively, Design Builder shall adjust the precise value of the x axis thresholds shown in the figure to provide stable control.
Below, the same diagram is separated into two diagrams for clarity and to illustrate the relative setpoints. However, both fan speed and supply air temperature setpoints are reset simultaneously and by the same signal – the value of the Heating Loop or Cooling Loop.

1) For a Heating Loop signal of 100% - 50%, fan speed is reset from MaxHeatSpeed to MinSpeed.
2) For a Heating Loop signal of 50% - 0%, fan speed setpoint is MinSpeed.

3) In Deadband, fan speed setpoint is MinSpeed.

4) For a Cooling Loop signal of 0% - 25%, fan speed is MinSpeed.

5) For a Cooling Loop signal of 25% - 50%, fan speed is reset from MinSpeed to MedSpeed.

6) For a Cooling Loop signal of 50% - 75%, fan speed is MedSpeed.

7) For a Cooling Loop signal of 75% - 100%, fan speed is reset from MedSpeed to MaxCoolSpeed.

8) For a Heating Loop signal of 100% - 50%, SATsp is Heat_SAT.

9) For a Heating Loop signal of 50% - 0%, SATsp is reset from Max_SAT to the Deadband value.

10) In Deadband, SATsp is the Deadband value.

11) For a Cooling Loop signal of 0% - 25%, SATsp is reset from the Deadband value to Cool_SAT minus 1.1°C (2°F), while SATsp-C is the Deadband value.

12) For a Cooling Loop signal of 25% - 50%, SATsp and SATsp-C are unchanged.
13) For a Cooling Loop signal of 50% - 75%, SATsp remains at Cool_SAT minus 1.1°C (2°F), SATsp-C is reset from the Deadband value to Cool_SAT.

14) For a Cooling Loop signal of 75% - 100%, SATsp and SATsp-C are unchanged.

3. Supply Air Temperature Control
   a. There are two supply air temperature setpoints, SATsp and SATsp-C. Each setpoint is maintained by a separate control loop but both loops use the same supply air temperature sensor.
   b. The control loop for SATsp is enabled when the supply air fan is proven on and disabled and set to Neutral otherwise.

1) Supply air temperature shall be controlled to SATsp by a control loop whose output is mapped to sequence the hot water valve or modulating electric heating coil (if applicable) and economizer dampers as shown in the diagram below. Outdoor air damper minimum (MinOA-P) and maximum (MaxOA-P) positions are limited for economizer lockout and to maintain minimum outdoor airflow rate as described in paragraph 4.11 D.4.

2) The points of transition along the x-axis shown below are representative. Separate gains shall be provided for each section of the control map (hot water, economizer, chilled water), that are determined by the Design Builder to provide stable control. Alternatively, Design Builder shall adjust the precise value of the x-axis thresholds shown in the figure to provide stable control.
4. Standard Alarms

a. Maintenance interval alarm when fan has operated for more than 1,500 hours: Level 4. Reset interval counter when alarm is acknowledged.

b. Fan alarm is indicated by the status being different from the command for a period of 15 seconds.
   
   1) Commanded on, status off: Level 2.
   2) Commanded off, status on: Level 4.

E. Filter pressure drop: BAS shall continuously monitor the filter differential pressure drop and alarm when the pressure drop exceed the alarm set point at maximum design air volume.

4.13 DVC – LIBRARY BUILDING 57 – AC-12 CONTROL

A. The air handling unit shall start and stop based on the preset schedule as determined by the College. Schedule shall include weekday start/stop occupied and unoccupied, weekends, and holidays.
B. When the unit is "off", the outside air damper is fully closed and the return air damper is fully open.

C. Warm up or cool down mode: During the initial startup, the air handling unit shall be in a warm up or cool down mode. During this mode, the economizer damper shall be in a 100% return air mode. Once the room temperature reaches 5 degrees (adjustable) above or below the set point, the AHU shall operate under normal mode.

D. In the occupied mode the BAS shall modulate the supply fan and sequence the economizer damper, heating coil control valve and chilled water control valve to maintain the room temperature setpoint at 75°F for cooling and 68°F for heating.

1. See Generic Thermal Zones for setpoints, loops, control modes, alarms, etc.

2. Supply Fan Speed Control and Supply Air Temperature Setpoint Reset
   a. The supply fan shall run whenever the unit is in any mode other than Unoccupied Mode.
   b. Provide a ramp function to prevent changes in fan speed of more than 10% per minute.
   c. Minimum, medium, and maximum fan speeds shall be as follows:
      1) Maximum cooling fan speed (MaxCoolSpeed), maximum heating fan speed (MaxHeatSpeed), and minimum fan speed (MinSpeed) setpoints shall be per ASHRAE Guideline 36 part 3.2B.1.
      2) Medium fan speed (MedSpeed) shall be reset linearly based on outdoor air temperature between the following endpoints.
         e) When the outdoor air temperature equals the zone temperature +0.56°C (1°F), Medspeed shall be MinSpeed.
         f) When the outdoor air temperature is 5.6°C (10°F) below the zone temperature, Medspeed shall be equal to MaxCoolSpeed.
   d. Minimum and maximum supply air temperature setpoints shall be as follows:
      1) Cool SAT and Heat SAT shall be determined based on the heating and cooling coil selection design temperatures.
      2) The Deadband values of SATsp and SATsp-C shall be the average of the zone heating setpoint and the zone cooling setpoint but shall be no lower than 21°C (70°F) and no higher than 24°C (75°F).
   e. When the supply fan is proven on, fan speed and supply air temperature setpoints are controlled as shown in the following diagrams and text.
points of transition along the x-axis shown and described below are representative. Separate gains shall be provided for each section of the control map (hot water, economizer, chilled water), that are determined by the Design Builder to provide stable control.

f. Alternatively, Design Builder shall adjust the precise value of the x-axis thresholds shown in the figure to provide stable control.

Below, the same diagram is separated into two diagrams for clarity and to illustrate the relative setpoints. However, both fan speed and supply air temperature setpoints are reset simultaneously and by the same signal – the value of the Heating Loop or Cooling Loop.
1) For a Heating Loop signal of 100% - 50%, fan speed is reset from MaxHeatSpeed to MinSpeed.

2) For a Heating Loop signal of 50% - 0%, fan speed setpoint is MinSpeed.

3) In Deadband, fan speed setpoint is MinSpeed.

4) For a Cooling Loop signal of 0% - 25%, fan speed is MinSpeed.

5) For a Cooling Loop signal of 25% - 50%, fan speed is reset from MinSpeed to MedSpeed.

6) For a Cooling Loop signal of 50% - 75%, fan speed is MedSpeed.

7) For a Cooling Loop signal of 75% - 100%, fan speed is reset from MedSpeed to MaxCoolSpeed.
8) For a Heating Loop signal of 100% - 50%, SATsp is Heat_SAT.

9) For a Heating Loop signal of 50% - 0%, SATsp is reset from Max_SAT to the Deadband value.

10) In Deadband, SATsp is the Deadband value.

11) For a Cooling Loop signal of 0% - 25%, SATsp is reset from the Deadband value to Cool_SAT minus 1.1°C (2°F), while SATsp-C is the Deadband value.

12) For a Cooling Loop signal of 25% - 50%, SATsp and SATsp-C are unchanged.

13) For a Cooling Loop signal of 50% - 75%, SATsp remains at Cool_SAT minus 1.1°C (2°F), SATsp-C is reset from the Deadband value to Cool_SAT.

14) For a Cooling Loop signal of 75% - 100%, SATsp and SATsp-C are unchanged.

3. Supply Air Temperature Control

   a. There are two supply air temperature setpoints, SATsp and SATsp-C. Each setpoint is maintained by a separate control loop but both loops use the same supply air temperature sensor.

   b. The control loop for SATsp is enabled when the supply air fan is proven on and disabled and set to Neutral otherwise.
1) Supply air temperature shall be controlled to SATsp by a control loop whose output is mapped to sequence the hot water valve or modulating electric heating coil (if applicable) and economizer dampers as shown in the diagram below. Outdoor air damper minimum (MinOA-P) and maximum (MaxOA-P) positions are limited for economizer lockout and to maintain minimum outdoor airflow rate as described in paragraph 4.11 D.4.

2) The points of transition along the x-axis shown below are representative. Separate gains shall be provided for each section of the control map (hot water, economizer, chilled water), that are determined by the Design Builder to provide stable control. Alternatively, Design Builder shall adjust the precise value of the x-axis thresholds shown in the figure to provide stable control.

c. The control loop for SATsp-C is enabled when the supply fan is proven on and the Zone State is Cooling and disabled and set to Neutral otherwise. When enabled, supply air temperature shall be controlled to SATsp-C by modulating the CHW valve.

4. Standard Alarms

a. Maintenance interval alarm when fan has operated for more than 1,500 hours: Level 4. Reset interval counter when alarm is acknowledged.
b. Fan alarm is indicated by the status being different from the command for a period of 15 seconds.

1) Commanded on, status off: Level 2.

2) Commanded off, status on: Level 4.

E. Filter pressure drop: BAS shall continuously monitor the filter differential pressure drop and alarm when the pressure drop exceed the alarm set point at maximum design air volume.

4.14 DVC – LIBRARY BUILDING 57 – AC-16 CONTROL

A. The air handling unit shall start and stop based on the preset schedule as determined by the College. Schedule shall include weekday start/stop occupied and unoccupied, weekend, and holidays.

B. Once the unit is energized, the BAS shall sequence the heating and cooling coil control valve to maintain the room temperature set point. There shall be no overlap between the operation of the heating and cooling coil control valves.

C. When the unit is “off” the outside air damper is fully closed and the return air is fully open.

D. Occupancy Override:

1. During the operating hours, if the room is unoccupied as sensed by the room occupancy sensors, stop the air handling unit and increase the room temperature setpoint dead band to -5 degree F below the heating setpoint and +5 degree above the cooling setpoint.

2. If the room is continuously unoccupied for one hour (adjustable), turn off the AC unit.

3. When the room temperature drops 5 degrees below or rises 5 degrees above the unoccupied room temperature setpoint, the BAS shall start the AHU to maintain the unoccupied room temperature. Once the room temperature is within 2 degrees of the dead band boundaries, turn off the AC unit. Limit the AHU cycling to 2 times/hour.

4. When the room is occupied, the BAS shall restart the AHU from the morning warm up or cool down mode.

5. Provide an adjustable time delay between occupied and unoccupied mode to minimize rapid transition between modes:

   a. From occupied to unoccupied: 10 minutes

   b. From unoccupied to occupied: 5 minutes

E. Filter Differential: The BAS shall continuously monitor the filter differential pressure drop and alarm when the filter pressure drop exceeds 0.75 in. w.c. (adjustable).
4.15 DVC – LIBRARY BUILDING 57 – AC-14 CONTROL

A. The air handling unit shall start and stop based on the preset schedule as determined by the College. Schedule shall include weekday start/stop occupied and unoccupied, weekend, and holidays.

B. Once the unit is energized, the BAS shall sequence the heating and cooling coil control valve to maintain the room temperature set point. There shall be no overlap between the operation of the heating and cooling coil control valves.

C. Filter Differential: The BAS shall continuously monitor the filter differential pressure drop and alarm when the filter pressure drop exceeds 0.75 in. w.c. (adjustable).

4.16 DVC – LIBRARY BUILDING 57 – FAN COIL UNIT OCCUPANCY CONTROL (FC-1, 2, 3, 4 AND FC-2.1, 2.2, 2.3, 2.4)

A. The fan coil unit shall start and stop based on the preset schedule as determined by the College. Schedule shall include weekday start/stop occupied and unoccupied, weekend, and holidays.

B. Once started the existing fan coil unit control shall sequence the heating and cooling system to maintain the room temperature setpoint.

C. Occupancy Override:
   1. During the operating hours, if the room is unoccupied as sensed by the room occupancy sensors, stop the fan coil unit.
   2. Start the fan coil unit when room is occupied.
   3. Provide an adjustable time delay between occupied and unoccupied mode to minimize rapid transition between modes:
      a. From occupied to unoccupied: 10 minutes
      b. From unoccupied to occupied: 5 minutes

4.17 DVC – LIBRARY BUILDING 57 – LIBRARY AREA HVAC SYSTEM

A. General

1. There will be multiple return fan serving the air intake plenum. Modulation of the return fans serving a plenum shall be synchronized (e.g. same modulation signal).

2. One of the return fan / economizer damper shall be used as the minimum outside air. The remaining unit economizer dampers shall be used for modulation.

3. The return fan shall module to maintain a slightly positive space pressure (± 0.05 in wc) and mixed air plenum pressure (± 0.01 in w.c.).
4. Each 4 pipe fan coil unit shall operate as a single zone VAV air handling unit.

B. AHU system Modes are the same as the Mode of the Zone Group served by the system. When Zone Group served by an air handling system are in different modes, the following hierarchy applies (highest one sets AHU mode).

1. Occupied Mode
2. Cool-down Mode
3. Setup Mode
4. Warmup Mode
5. Setback Mode
6. Freeze Protection Setback Mode
7. Unoccupied Mode

C. Supply Fan Control

1. Supply and Return Fan Start/Stop
   a. Supply and Return fan shall run when system is in the Cool-down Mode, Setup Mode, or Occupied Mode.
   b. If there are any VAV-AHU on perimeter zones, supply fan shall also run when system is in Setback Mode or Warmup Mode (i.e., all Modes except Unoccupied).

D. Mixed Air Temperature Control

1. Control loop is enabled when the supply and return air fan is proven on and disabled and output set to Deadband (no heating, minimum economizer) otherwise.

2. Supply Air Temperature Setpoint
   a. See 3.1D.1 for Min_MAT, Max_MAT, OAT_Min, and OAT_Max setpoints.
   b. During Occupied Mode and Setup Mode: Setpoint shall be reset from Min_MAT when the outdoor air temperature is OAT_Max and above, proportionally up to T-max when the outdoor air temperature is OAT_Min and below.

   1) T-max shall be reset using Trim & Respond logic [see 5.1N] between Min_SAT and Max_SAT. The following parameters are suggested as a starting place but they will require adjustment during the commissioning/tuning phase.
The net result of this SAT reset strategy is depicted in the chart below for Min_MAT = 12°C (53°F), Max_MAT = 18°C (tbd), OAT_Max=21°C (70°F), and OAT_Min = 16°C (60°F):

c. During Cool-Down Mode: Setpoint shall be Min_MAT.

d. During Warmup and Setback Modes: Setpoint shall be 35°C (95°F) (TBD).

3. Mixed air temperature shall be controlled to setpoint using a control loop whose output is mapped to sequence the, outdoor air damper, and return air damper, as shown in the diagram below.
a. Economizer damper maximum (MaxOA-P) position is limited for economizer high limit lockout [TBD].

b. For units with a separate minimum outdoor air damper: MinOA-P is 0% and MaxRA-P is modulated to control minimum outdoor air volume [see 5.14C.3 and 5.14D].

c. The points of transition along the x-axis shown and described below are representative. Separate gains shall be provided for each section of the control map (hot water, economizer, chilled water) that are determined by the Design Builder to provide stable control. Alternatively, Design Builder shall adjust the precise value of the x-axis thresholds shown in the figure to provide stable control.

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### E. Minimum Outdoor Airflow Setpoints

1. Outdoor airflow setpoint, for California Title 24 ventilation:
   
   a. See 5.2B.5.b for zone outdoor air rates Zone-Abs-OA-min and Zone-Des-OA-min.

   b. See 3.1D.2.b for setpoints AbsMinOA and DesMinOA:

   c. Effective outdoor air absolute minimum and design minimum setpoints are recalculated continuously based on the Mode of the zones being served.
1) AbsMinOA* is the sum of Zone-Abs-OA-min for all zones in all Zone Groups that are in Occupied Mode but shall be no larger than the absolute minimum outdoor airflow, AbsMinOA.

2) DesMinOA* is the sum of Zone-Des-OA-min for all zones in all Zone Groups that are in Occupied Mode but shall be no larger than the design minimum outdoor airflow, DesMinOA.

2. DP setpoint, for California Title 24 ventilation
   a. See 3.2A.5 for design OA DP setpoints.
   b. See 5.14C.2.c for calculation of current setpoints, AbsMinOA* and DesMinOA*.
   c. See zone CO2 control logic under terminal unit sequences.
   d. The active minimum differential pressure setpoints, AbsDPsp* and DesDPsp*, shall be determined by the equations below:

\[
\text{AbsDPsp}^* = \text{AbsMinDP} \left[ \frac{\text{AbsMinOA}^*}{\text{AbsMinOA}} \right] \]

\[
\text{DesDPsp}^* = \text{DesMinDP} \left[ \frac{\text{DesMinOA}^*}{\text{DesMinOA}} \right] \]

   e. The minimum outdoor air DP setpoint (MinDPsp) shall be reset based on the highest zone CO2 control loop signal from AbsDPsp* at 50% signal to DesDPsp* at 100% signal.
   f. The minimum outdoor air setpoint (MinOAsp) shall be reset based on the highest zone CO2 control loop signal from AbsMinOA* at 50% signal to DesMinOA* at 100% signal.

3. Open minimum outdoor air damper when the supply air fan is proven on and the system is in Occupied Mode and MinDPsp is greater than zero. Damper shall be closed otherwise.

4. Return air dampers
   a. Return air damper minimum outdoor air control is enabled when the minimum outdoor air damper is open and the economizer outdoor air damper is less than MOA-P where MOA-P is 5% when supply fan speed is at 100% design speed proportionally up to 80% when the fan is at minimum speed.
b. Return air damper minimum outdoor air control is disabled when the minimum outdoor air damper is closed or the economizer outdoor air damper is 10% above MOA-P determined above.

c. When enabled, the maximum RA damper setpoint, MaxRA-P, is modulated from 100% to 0% to maintain differential pressure across the minimum outdoor air damper at setpoint, MinDPsp.

F. Minimum Outdoor Air Control with a separate minimum outdoor air damper and airflow measurement

1. Outdoor airflow setpoint, for California Title 24 ventilation:
   a. See 5.14C.2.c for calculation of current setpoints, AbsMinOA* and DesMinOA*.
   b. See zone CO2 control logic under terminal unit sequences.
   c. The minimum outdoor air setpoint MinOAsp shall be reset based on the highest zone CO2 control loop signal from AbsMinOA* at 50% signal to DesMinOA* at 100% signal.

2. Minimum Outdoor Air Control Loop
   a. Minimum outdoor air control loop is enabled when the supply fan is proven on and in Occupied Mode and disabled and output set to zero otherwise.
   b. The minimum outdoor airflow rate shall be maintained at the minimum outdoor air setpoint MinOAsp by a reverse-acting control loop whose output is 0-100%. From 0% to 50% loop output, the minimum outdoor air damper is opened from 0% to 100%.
   c. Return air dampers
      1) Return air damper minimum outdoor air control is enabled when the minimum outdoor air damper is 100% open and the economizer outdoor air damper is less than MOA-P where MOA-P is 5% when supply fan speed is at 100% design speed proportionally up to 80% when the fan is at minimum speed.

G. Economizer High Limit Lockout

1. The normal sequencing of the economizer dampers (above) shall be disabled in accordance with 5.1Q.

2. When economizer is enabled, MaxOA-P = 100%.
3. Once the economizer is disabled, it shall not be re-enabled within 10 minutes, and vice versa.

4. When the economizer is disabled:
   a. Return air damper shall be fully opened
   b. Wait 15 seconds, then set MaxOA-P equal to MinOA-P.
   c. Wait 3 minutes, then release return air damper for minimum outdoor air control.

H. Return Fan Control – Direct Building Pressure
   1. Return fan operates whenever associated supply fan is proven on and shall be off otherwise.
   2. Return fans shall be controlled to maintain return fan discharge static pressure at setpoint (see below).
   3. Building static pressure shall be time averaged with a sliding 5-minute window (to dampen fluctuations). The averaged value shall be that displayed and used for control.

I. Single Zone VAV Air Handling Unit
   1. See Generic Thermal Zones for setpoints, loops, control modes, alarms, etc.
   2. Supply Fan Speed Control and Supply Air Temperature Setpoint Reset
      a. The supply fan shall run whenever the unit is in any mode other than Unoccupied Mode.
      b. Provide a ramp function to prevent changes in fan speed of more than 10% per minute.
      c. Minimum, medium, and maximum fan speeds shall be as follows:
         1) Maximum cooling fan speed (MaxCoolSpeed), maximum heating fan speed (MaxHeatSpeed), and minimum fan speed (MinSpeed) setpoints shall be per 3.2B.1.
         2) Medium fan speed (MedSpeed) shall be reset linearly based on outdoor air temperature between the following endpoints.
            a) When the outdoor air temperature equals the zone temperature +0.56°C (1°F), Medspeed shall be MinSpeed.
b) When the outdoor air temperature is 5.6°C (10°F) below the zone temperature, Medspeed shall be equal to MaxCoolSpeed.

d) Minimum and maximum supply air temperature setpoints shall be as follows:

1) Cool_SAT and Heat_SAT shall be per 3.1F.1.

2) The Deadband values of SATsp and SATsp-C shall be the average of the zone heating setpoint and the zone cooling setpoint but shall be no lower than 21°C (70°F) and no higher than 24°C (75°F).

e) When the supply fan is proven on, fan speed and supply air temperature setpoints are controlled as shown in the following diagrams and text. The points of transition along the x-axis shown and described below are representative. Separate gains shall be provided for each section of the control map (hot water, economizer, chilled water), that are determined by the Design Builder to provide stable control. Alternatively, Design Builder shall adjust the precise value of the x-axis thresholds shown in the figure to provide stable control.

Below, the same diagram is separated into two diagrams for clarity and to illustrate the relative setpoints. However, both fan speed and supply air temperature setpoints are reset simultaneously and by the same signal – the value of the Heating Loop or Cooling Loop.
1) For a Heating Loop signal of 100% - 50%, fan speed is reset from MaxHeatSpeed to MinSpeed.

2) For a Heating Loop signal of 50% - 0%, fan speed setpoint is MinSpeed.

3) In Deadband, fan speed setpoint is MinSpeed.

4) For a Cooling Loop signal of 0% - 25%, fan speed is MinSpeed.

5) For a Cooling Loop signal of 25% - 50%, fan speed is reset from MinSpeed to MedSpeed.

6) For a Cooling Loop signal of 50% - 75%, fan speed is MedSpeed.

7) For a Cooling Loop signal of 75% - 100%, fan speed is reset from MedSpeed to MaxCoolSpeed.
8) For a Heating Loop signal of 100% - 50%, SATsp is Heat_SAT.

9) For a Heating Loop signal of 50% - 0%, SATsp is reset from Max_SAT to the Deadband value.

10) In Deadband, SATsp is the Deadband value.

11) For a Cooling Loop signal of 0% - 25%, SATsp is reset from the Deadband value to Cool_SAT minus 1.1°C (2°F), while SATsp-C is the Deadband value.

12) For a Cooling Loop signal of 25% - 50%, SATsp and SATsp-C are unchanged.

13) For a Cooling Loop signal of 50% - 75%, SATsp remains at Cool_SAT minus 1.1°C (2°F), SATsp-C is reset from the Deadband value to Cool_SAT.

14) For a Cooling Loop signal of 75% - 100%, SATsp and SATsp-C are unchanged.

3. Supply Air Temperature Control
   a. There are two supply air temperature setpoints, SATsp and SATsp-C. Each setpoint is maintained by a separate control loop but both loops use the same supply air temperature sensor.
   b. The control loop for SATsp is enabled when the supply air fan is proven on and disabled and set to Neutral otherwise.
1) Supply air temperature shall be controlled to SATsp by a control loop whose output is mapped to sequence the hot water valve or modulating electric heating coil (if applicable) and economizer dampers as shown in the diagram below. Outdoor air damper minimum (MinOA-P) and maximum (MaxOA-P) positions are limited for economizer lockout and to maintain minimum outdoor airflow rate as described in paragraphs 5.16D and 5.16E.

2) The points of transition along the x-axis shown below are representative. Separate gains shall be provided for each section of the control map (hot water, economizer, chilled water), that are determined by the Design Builder to provide stable control. Alternatively, Design Builder shall adjust the precise value of the x-axis thresholds shown in the figure to provide stable control.

3) The control loop for SATsp-C is enabled when the supply fan is proven on and the Zone State is Cooling and disabled and set to Neutral otherwise. When enabled, supply air temperature shall be controlled to SATsp-C by modulating the CHW valve.

J. Freeze Protection

1. If the supply air temperature drops below 4.4°C (40°F) for 5 minutes, send two (or more, as required to ensure that heating plant is active) Boiler Plant Requests, override the outdoor air damper to the minimum position and modulate the heating coil to maintain a supply air temperature of at least 5.6°C (42°F). Disable this function when supply air temperature rises above 7.2°C (45°F) for 5 minutes.

2. If the supply air temperature drops below 3.3°C (38°F) for 5 minutes, fully close both the economizer damper and the minimum outdoor air damper for one hour, and set a Level 3 alarm noting that minimum ventilation was interrupted. After one hour, the unit shall resume minimum outdoor air ventilation and enter the previous stage of freeze protection (see 5.14K.1).

3. Upon signal from supply air temperature drops below 3.3°C (38°F) for 15 minutes or below 1.1°C (34°F) for 5 minutes, shut down supply and return/relief fan(s), close outdoor air damper, open the cooling coil valve to 100%, and energize the chilled water pump system. Also, send two (or more, as required to ensure that heating plant is active) Boiler Plant Requests, modulate the heating coil to maintain the higher of the supply air temperature or the mixed air temperature at 27°C (80°F), and set a Level 2 alarm indicating the unit is shut down by freeze protection.

   a. If a freeze protection shutdown is triggered by a low air temperature sensor reading, it shall remain in effect until it is reset by a software switch from the operator’s workstation. (If a freeze stat with a physical reset switch is used instead, there shall be no software reset switch.)

K. Alarms
1. Maintenance interval alarm when fan has operated for more than 1,500 hours: Level 4. Reset interval count when alarm is acknowledged.

2. Fan alarm is indicated by the status being different from the command for a period of 15 seconds.
   a. Commanded on, status off: Level 2
   b. Commanded off, status on: Level 4

3. Filter pressure drop exceeds alarm limit: Level 4. The alarm limit shall vary with total airflow (if available; use fan speed if total airflow is not known) as follows:

   \[ \frac{DP_x}{DP_{100}} = (\frac{x}{1.4})^{100} \]

   where DP100 is the high limit pressure drop at design airflow (determine limit from filter manufacturer) and DPx is the high limit at the current airflow rate x (expressed as a fraction). For instance, the setpoint at 50% of design airflow would be \((.5)^{1.4}\) or 38% of the design high limit pressure drop.

4. High building pressure (more than 25 Pa (0.10”)): Level 3

5. Low building pressure (less than 0 Pa (0.0”), i.e. negative): Level 4

L. Automatic Fault Detection and Diagnostics

1. AFDD conditions are evaluated continuously and separately for each operating air handling unit.

2. The Operating State (OS) of each AHU shall be defined by the commanded positions of the heating coil control valve, cooling coil control valve, and economizer damper in accordance with the following table and corresponding graphic.
3. The following points must be available to the AFDD routines for each AHU.
   a. SAT = Supply air temperature
   b. MAT = Mixed air temperature
   c. RAT = Return air temperature
   d. OAT = Outdoor air temperature
   e. DSP = Duct static pressure
f. SATSP = supply air temperature setpoint

g. DSPSP = duct static pressure setpoint

h. HC = heating coil valve position command; 0% ≤ HC ≤ 100%

i. CC = cooling coil valve position command; 0% ≤ CC ≤ 100%

j. FS = fan speed command; 0% ≤ FS ≤ 100%

k. CCET = cooling coil entering temperature; depending on the AHU configuration, this could be the MAT or a separate sensor for this specific purpose.

l. CCLT = cooling coil leaving temperature; depending on the AHU configuration, this could be the SAT or a separate sensor for this specific purpose.

m. HCET = heating coil entering temperature; depending on the AHU configuration, this could be the MAT or a separate sensor for this specific purpose.

n. HCLT = heating coil leaving temperature; depending on the AHU configuration, this could be the SAT or a separate sensor for this specific purpose.

4. The following values must be continuously calculated by the AFDD routines for each AHU:

a. 5-minute rolling averages with 1-minute sampling time of the following point values; operator shall have the ability to adjust the averaging window and sampling period for each point independently

1) SATAVG = rolling average of supply air temperature.

2) MATAVG = rolling average of mixed air temperature

3) ATAVG = rolling average of return air temperature

4) OATAVG = rolling average of outdoor air temperature

5) DSPAVG = rolling average of duct static pressure

6) CCETAVG = rolling average of cooling coil entering temperature

7) CCLTAVG = rolling average of cooling coil leaving temperature

8) HCETAVG = rolling average of heating coil entering temperature

9) HCLTAVG = rolling average of heating coil leaving temperature
b. \( \%OA = \text{actual outdoor air fraction as a percentage} = \frac{\text{MAT} - \text{RAT}}{\text{OAT} - \text{RAT}} \) 

\( \%OAMIN = \text{Active minimum OA setpoint (MinOAsp) divided by actual total airflow (from sum of VAV box flows, or by airflow measurement station) as a percentage.} \)

d. \( \Delta OS = \text{number of changes in Operating State during the previous 60 minutes (moving window).} \)

5. The following internal variables shall be defined for each AHU. All parameters are adjustable by the operator, with initial values as given below:

<table>
<thead>
<tr>
<th>Variable Name</th>
<th>Description</th>
<th>Default Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \Box )TSF</td>
<td>Temperature rise across supply fan</td>
<td>1.1°C (2°F)</td>
</tr>
<tr>
<td>( \Box )TMIN</td>
<td>Minimum difference between OAT and RAT to evaluate economizer error conditions (FC#6)</td>
<td>5.6°C (10°C)</td>
</tr>
<tr>
<td>( \Box )SAT</td>
<td>Temperature error threshold for SAT sensor</td>
<td>1.1°C (2°F)</td>
</tr>
<tr>
<td>( \Box )RAT</td>
<td>Temperature error threshold for RAT sensor</td>
<td>1.1°C (2°F)</td>
</tr>
<tr>
<td>( \Box )MAT</td>
<td>Temperature error threshold for MAT sensor</td>
<td>2.7°C (5°F)</td>
</tr>
<tr>
<td>( \Box )OAT</td>
<td>Temperature error threshold for OAT sensor</td>
<td>1.1°C (2°F) if local sensor at unit. 2.7°C (5°F) if global sensor.</td>
</tr>
<tr>
<td>( \Box )F</td>
<td>Airflow error threshold</td>
<td>30%</td>
</tr>
<tr>
<td>( \Box )VFDS</td>
<td>VFD speed error threshold</td>
<td>5%</td>
</tr>
<tr>
<td>( \Box )DSP</td>
<td>Duct static pressure error threshold</td>
<td>25 Pa (0.1&quot;)</td>
</tr>
<tr>
<td>( \Box )CCET</td>
<td>Cooling coil entering temperature sensor error. Equal to ( \Box )MAT or dedicated sensor error</td>
<td>Varies, see Description</td>
</tr>
<tr>
<td>( \Box )CCLT</td>
<td>Cooling coil leaving temperature sensor error. Equal to ( \Box )SAT or dedicated sensor error</td>
<td></td>
</tr>
<tr>
<td>( \Box )HCET</td>
<td>Heating coil entering temperature sensor error; equal to ( \Box )MAT or dedicated sensor error</td>
<td></td>
</tr>
<tr>
<td>( \Box )HCLT</td>
<td>Heating coil leaving temperature sensor error. Equal to ( \Box )SAT or dedicated sensor error</td>
<td></td>
</tr>
<tr>
<td>( \Box )OSMAX</td>
<td>Maximum number of changes in Operating State during the previous 60 minutes (moving window)</td>
<td>7</td>
</tr>
</tbody>
</table>
6. The following are potential Fault Conditions that can be evaluated by the AFDD routines. If the equation statement is true, then the specified fault condition exists. The Fault Conditions to be evaluated at any given time will depend on the Operating State of the AHU.

<table>
<thead>
<tr>
<th>Fault Condition</th>
<th>Equation</th>
<th>Description</th>
<th>Possible Diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>DSP too low</td>
<td>DSP &lt; DSPSP - $\epsilon_{DSP}$</td>
<td>Duct static pressure is too low with fan at full speed</td>
<td>SAT Setpoint too high (too much zone demand)</td>
</tr>
<tr>
<td></td>
<td>and VFDSPD $\geq 99% - \epsilon_{VFDSPD}$</td>
<td>Problem with VFD</td>
<td>Mechanical problem with fan</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fan undersized</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fault Condition</th>
<th>Equation</th>
<th>Description</th>
<th>Possible Diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAT too low</td>
<td>MATAVG + $\epsilon_{MAT}$ &lt; min ((RATAVG - \epsilon_{RAT}), (OATAVG - \epsilon_{OAT}))</td>
<td>MAT too low; should be between OAT and RAT</td>
<td>MAT sensor error</td>
</tr>
<tr>
<td></td>
<td></td>
<td>RAT sensor error</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>MAT sensor error</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>OAT sensor error</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fault Condition</th>
<th>Equation</th>
<th>Description</th>
<th>Possible Diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAT too high</td>
<td>MATAVG - $\epsilon_{MAT}$ &gt; max ((RATAVG + \epsilon_{RAT}), (OATAVG + \epsilon_{OAT}))</td>
<td>MAT too high; should be between OAT and RAT</td>
<td>MAT sensor error</td>
</tr>
<tr>
<td></td>
<td></td>
<td>RAT sensor error</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>MAT sensor error</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>OAT sensor error</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fault Condition</th>
<th>Description</th>
<th>Possible Diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Too many changes in Operating State</td>
<td>Unstable control due to poorly tuned loop or mechanical problem</td>
<td></td>
</tr>
<tr>
<td>FC#</td>
<td>Equation</td>
<td>Description</td>
</tr>
<tr>
<td>-----</td>
<td>----------</td>
<td>-------------</td>
</tr>
<tr>
<td>5</td>
<td>$\text{SAT}<em>{\text{AVG}} + \epsilon</em>{\text{SAT}} \leq \text{MAT}<em>{\text{AVG}} - \epsilon</em>{\text{MAT}} + \Delta T_{\text{SF}}$</td>
<td>SAT too low; should be higher than MAT</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SAT sensor error</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MAT sensor error</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>$</td>
<td>\text{RAT}<em>{\text{AVG}} - \text{OAT}</em>{\text{AVG}}</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>$\text{SAT}<em>{\text{AVG}} &lt; \text{SAT}</em>{\text{SP}} - \epsilon_{\text{SAT}}$ and $\text{HC} \geq 99%$</td>
<td>SAT too low in full heating</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SAT sensor error</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cooling coil valve leaking or stuck open</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Heating coil valve stuck closed or actuator failure</td>
</tr>
<tr>
<td></td>
<td></td>
<td>HW temperature too low or HW unavailable</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Leaking or stuck economizer damper or actuator</td>
</tr>
<tr>
<td>8</td>
<td>$</td>
<td>\text{SAT}<em>{\text{AVG}} - \Delta T</em>{\text{SF}} - \text{MAT}_{\text{AVG}}</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SAT sensor error</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MAT sensor error</td>
</tr>
</tbody>
</table>

**Applies to OS**

- **#1**: C-1129 PAC Boiler Replacement
- **#2**: C-1131 AT Packaged Unit Replacement
- **#3**: C-1130 PAC Chiller Replacement
- **#4**: D-1044 Campus-Wide EMS Upgrades
- **#5**: D-4017 Mechanical Equipment Retrofit
- **#6**: P-4022 AHU Replacement
<table>
<thead>
<tr>
<th>FC#</th>
<th>Equation</th>
<th>Description</th>
<th>Possible Diagnosis</th>
</tr>
</thead>
</table>
| FC#9  | $OAT_{AVG} - \varepsilon_{OAT} > SAT_{SP} - \Delta T_{SF} + \varepsilon_{SAT}$ | OAT is too high for free cooling without additional mechanical cooling | SAT sensor error  
OAT sensor error  
Cooling coil valve leaking or stuck open |
|       |                                       | Applies to OS #2                                |                                             |
| FC#10 | \[|MAT_{AVG} - OAT_{AVG}| > J \varepsilon_{MAT}^2 + \varepsilon_{OAT}^2\] | OAT and MAT should be approximately equal         | MAT sensor error  
OAT sensor error  
Leaking or stuck economizer damper or actuator |
|       |                                       | Applies to OS #3                                |                                             |
| FC#11 | $OAT_{AVG} + \varepsilon_{OAT} < SAT_{SP} - \Delta T_{SF} - \varepsilon_{SAT}$ | OAT is too low for 100% OA cooling                | SAT sensor error  
OAT sensor error  
Heating coil valve leaking or stuck open  
Leaking or stuck economizer damper or actuator |
|       |                                       | Applies to OS #3                                |                                             |
| FC#12 | $SAT_{AVG} - \varepsilon_{SAT} - \Delta T_{SF} \geq MA T_{AVG} + \varepsilon_{MAT}$ | SAT too high; should be less than MAT            | SAT sensor error  
MAT sensor error  
Cooling coil valve stuck closed or actuator failure  
Fouled or undersized cooling coil  
CHW temperature too high or CHW unavailable  
Heating coil valve leaking or stuck open |
|       |                                       | Applies to OS #3, #4                           |                                             |
| FC#13 | \[SAT_{AVG} > SAT_{SP} + \varepsilon_{SAT} \text{ and } CC \geq 99\%\] | SAT too high in full cooling                     | SAT sensor error  
Cooling coil valve stuck closed or actuator failure  
Fouled or undersized cooling coil  
CHW temperature too high or CHW unavailable  
Heating coil valve leaking or stuck open |
|       |                                       | Applies to OS #3, #4                           |                                             |
**FC#14**  
**Equation**  
\[ \text{CCET}_{\text{AVG}} - \text{CCLT}_{\text{AVG}} \geq J \varepsilon_{\text{ET}}^2 + \varepsilon_{\text{LT}}^2 + \Delta T_{\text{SF}}^2 \]  
*Fan heat factor included or not depending on location of sensors used for CCET and CCLT*

**Description**  
Temperature drop across inactive cooling coil

**Possible Diagnosis**  
- CCET sensor error
- CCLT sensor error
- Cooling coil valve stuck open or leaking.

**Appplies to OS #1, #2**

---

**FC#15**  
**Equation**  
\[ \text{HCLT}_{\text{AVG}} - \text{HCET}_{\text{AVG}} \geq J \varepsilon_{\text{ET}}^2 + \varepsilon_{\text{LT}}^2 + \Delta T_{\text{SF}}^2 \]  
*Fan heat factor included or not depending on location of sensors used for HCET and HCLT*

**Description**  
Temperature rise across inactive heating coil

**Possible Diagnosis**  
- HCET sensor error
- HCLT sensor error
- Heating coil valve stuck open or leaking.

**Appplies to OS #2 – #4**

---

7. A subset of all potential fault conditions is evaluated by the AFDD routines. The set of applicable fault conditions depends on the Operating State of the AHU:

a. In OS #1 (Heating), the following Fault Conditions shall be evaluated:
   1) FC#1: Duct static pressure is too low with fan at full speed
   2) FC#2: MAT too low; should be between RAT and OAT
   3) FC#3: MAT too high; should be between RAT and OAT
   4) FC#4: Too many changes in Operating State
   5) FC#5: SAT too low; should be higher than MAT
   6) FC#6: OA fraction is too low or too high; should equal %OAMIN
   7) FC#7: SAT too low in full heating
   8) FC#14: Temperature drop across inactive cooling coil

b. In OS#2 (Modulating Economizer), the following Fault Conditions shall be evaluated:
   1) FC#1: Duct static pressure is too low with fan at full speed
   2) FC#2: MAT too low; should be between RAT and OAT
   3) FC#3: MAT too high; should be between RAT and OAT
4) FC#4: Too many changes in Operating State
5) FC#8: SAT and MAT should be approximately equal
6) FC#9: OAT is too high for free cooling without mechanical cooling
7) FC#14: Temperature drop across inactive cooling coil
8) FC#15: Temperature rise across inactive heating coil

c. In OS#3 (Mechanical + 100% Economizer Cooling), the following Fault Conditions shall be evaluated:
1) FC#1: Duct static pressure is too low with fan at full speed
2) FC#2: MAT too low; should be between RAT and OAT
3) FC#3: MAT too high; should be between RAT and OAT
4) FC#4: Too many changes in Operating State
5) FC#10: OAT and MAT should be approximately equal
6) FC#11: OAT too low for 100% OA
7) FC#12: SAT too high; should be less than MAT
8) FC#13: SAT too high in full cooling
9) FC#15: Temperature rise across inactive heating coil

d. In OS#4 (Mechanical Cooling, Min OA), the following Fault Conditions shall be evaluated:
1) FC#1: Duct static pressure is too low with fan at full speed
2) FC#2: MAT too low; should be between RAT and OAT
3) FC#3: MAT too high; should be between RAT and OAT
4) FC#4: Too many changes in Operating State
5) FC#6: OA fraction is too low or too high; should equal %OAMIN
6) FC#12: SAT too high; should be less than MAT
7) FC#13: SAT too high in full cooling
8) FC#15: Temperature rise across inactive heating coil
e. In OS#5 (Other), the following Fault Conditions shall be evaluated:

1) FC#1: Duct static pressure is too low with fan at full speed
2) FC#2: MAT too low; should be between RAT and OAT
3) FC#3: MAT too high; should be between RAT and OAT
4) FC#4: Too many chances in Operating State

8. For each air handler, the operator shall be able to suppress the alarm for any Fault Condition.

9. Evaluation of Fault Conditions shall be suspended under the following conditions:

a. When AHU is not operating.

b. For a period of ModeDelay minutes following a change in Mode (e.g., from Warm up to Occupied) of any Zone Group served by the AHU.

10. Fault Conditions that are not applicable to the current Operating State shall not be evaluated.

11. A Fault Condition that evaluates as true must do so continuously for AlarmDelay minutes before it is reported to the operator.

12. Test Mode shall temporarily set ModeDelay and AlarmDelay to 0 minutes for a period of TestModeDelay minutes to allow instant testing of the AFDD system and ensure normal fault detection occurs after testing is complete.

13. When a Fault Condition is reported to the operator, it shall be a Level 3 alarm and shall include the description of the fault and the list of possible diagnoses from the table in 5.14M.6.

M. Testing/Commissioning Overrides: Provide software switches that interlock to a chilled water and hot water plant level to

1. If there is a hot water coil, force hot water valve full open
2. If there is a hot water coil, force hot water valve full closed
3. Force chilled water valve full open
4. Force chilled water valve full closed
4.18 DVC – PHYSICAL SCIENCE BUILDING #92

A. Integrate the new control sequence to the existing AC unit and VAV terminals Direct Digital Control system and sequence.

B. VAV Terminals:

1. Occupancy Override: During operating hours, if the room is unoccupied as sensed by the room occupancy sensors, position the VAV terminal as follow:
   a. Set the VAV air flow to minimum flow.
   b. Reset the cooling room temperature set point to +5 degrees above the normal cooling setpoint.
   c. Reset the heating room temperature setpoint to -5 degrees below the normal heating setpoint.
   d. Provide an adjustable time delay between occupied and unoccupied mode to minimize rapid transition between modes:
      1) From occupied to unoccupied: 10 minutes
      2) From unoccupied to occupied: 5 minutes
   e. For VAV terminal serving multiple rooms, the VAV terminal shall not switch to unoccupied mode until all the rooms are unoccupied, and shall switch to occupied mode when any one of the rooms is occupied.

2. CO2 Control (For Classrooms only).
   a. The BAS shall continuously monitor the space CO2 level.
   b. Provide CO2 control per Section 4.02 B.2.
   c. Send a high CO2 level alarm when the outside air damper is about 80% open and the room CO2 level is still above 1000 ppm.
   d. When the room CO2 level drops below 1000 ppm, the BAS shall modulate the outside air damper and VAV terminal back to its normal operating position.

3. AC-3 Fan Static Pressure Reset
   a. The BAS shall reset the duct static pressure setpoint to maintain the VAV terminal damper with the highest airflow demand at 90% (adjustable) open.
4.19 CCCD BUILDING – DUAL DUCT DUAL FAN SYSTEM CONTROL

A. Integrate the new AHU into the Building BAS system. VAV terminals are existing. The control and feedback of these terminals shall be integrated to the AHU control as required.

B. Air Handling Unit System Modes:

1. AHU system modes are the same as the mode of the Isolation Areas served by the system. When Isolation Areas served by an air handling system are in different modes, the following hierarchy applies (highest one sets AHU mode):

   a. Occupied mode
   b. Cool-down mode
   c. Setup mode
   d. Warm-up mode
   e. Setback mode
   f. Unoccupied mode

C. DFDD VAV Air Handling System

1. Cooling Supply fan control.

   a. Cooling fan start/stop:

      1) AH unit fan shall be enabled when system is in the Cool-down Mode, Setup Mode, or Occupied Mode.

      2) Fan Optimization

         a) The Internal AHU airflow/fan modulation control shall perform calculations and stage the fans and/or modulate the fan speed to maintain the duct static pressure set point.

         3) Fan speed shall be controlled to rise very slowly to prevent high pressure trips in case all VAV boxes are closed (they should close during unoccupied periods) or in case fire/smoke dampers are closed (in some FSD designs, the dampers are interlocked to the fan status rather than being controlled by smoke detectors).

         4) Fan VFDs shall be hard-wire interlocked through high discharge and low mixed air static pressure safety relays mounted in the control panel. The relay energizes when high-limit DP switches sense pressure above 4.0” (adj.) at the fan discharge or -1.5” (adj.) in the mixed air plenum relative to the return air plenum,
locking out the fans until they are reset by the reset DO point or a push-button on the panel face. A pilot light on the panel face indicates static pressure safety lockout is in effect.

b. Totalize current airflow rate from VAV boxes to a software point.

c. Static Pressure Setpoint Reset

1) Static pressure setpoint: Setpoint shall be reset using Trim & Respond logic [TBD] using the following parameters.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Device</td>
<td>Supply Fan</td>
</tr>
<tr>
<td>SP0</td>
<td>120 Pa. (0.5 inches)</td>
</tr>
<tr>
<td>SPmin</td>
<td>25 Pa. (0.1 inches)</td>
</tr>
<tr>
<td>SPmax</td>
<td>Max_DSP (See 3.2A.1)</td>
</tr>
<tr>
<td>Td</td>
<td>10 minutes</td>
</tr>
<tr>
<td>T</td>
<td>2 minutes</td>
</tr>
<tr>
<td>I</td>
<td>2</td>
</tr>
<tr>
<td>R</td>
<td>Zone Static Pressure Reset</td>
</tr>
<tr>
<td>SPtrim</td>
<td>-12 Pa (-0.05 inches)</td>
</tr>
<tr>
<td>SPres</td>
<td>15 Pa (+0.06 inches)</td>
</tr>
<tr>
<td>SPres-max</td>
<td>32 Pa (+0.13 inches)</td>
</tr>
</tbody>
</table>

d. Static Pressure Control

1) Supply fan speed is controlled to maintain duct static pressure at setpoint when the fan is proven on. Where the Zone Groups served by the system are small, provide multiple sets of gains that are used in the control loop as a function of a load indicator (such as supply fan airflow rate, the area of the Zone Groups that are occupied, etc.).

2. Heating Supply Fan Control

a. Fan shall run when system is in the Warmup Mode and Setback Mode and during Occupied Mode while there are any Heating Fan Requests with a minimum runtime of 15 minutes.

b. Totalize current airflow rate from VAV boxes to a software point, Vps.
c. Static Pressure Setpoint Reset

1) Static pressure setpoint: Setpoint shall be reset using Trim & Respond logic [TBD] using the following parameters.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Device</td>
<td>Supply Fan</td>
</tr>
<tr>
<td>SP0</td>
<td>120 Pa. (0.5 inches)</td>
</tr>
<tr>
<td>SP min</td>
<td>25 Pa. (0.1 inches)</td>
</tr>
<tr>
<td>SP max</td>
<td>Max_DSP (See 3.2A.1)</td>
</tr>
<tr>
<td>Td</td>
<td>10 minutes</td>
</tr>
<tr>
<td>T</td>
<td>2 minutes</td>
</tr>
<tr>
<td>I</td>
<td>2</td>
</tr>
<tr>
<td>R</td>
<td>Zone Static Pressure Reset</td>
</tr>
<tr>
<td>SP trim</td>
<td>-12 Pa (-0.05 inches)</td>
</tr>
<tr>
<td>SP res</td>
<td>15 Pa (+0.06 inches)</td>
</tr>
<tr>
<td>SP res-max</td>
<td>32 Pa (+0.13 inches)</td>
</tr>
</tbody>
</table>

d. Static Pressure Control

1) Supply fan speed is controlled to maintain duct static pressure at setpoint when the fan is proven on. Where the Zone Groups served by the system are small, provide multiple sets of gains that are used in the control loop as a function of a load indicator (such as supply fan airflow rate, the area of the Zone Groups that are occupied, etc.).

3. Cooling supply air temperature control

a. Cooling supply air temperature control loop is enabled when the cooling supply air fan is proven on, and disabled and output set to zero otherwise. When loop is disabled, slowly reduce loop output to zero to prevent sudden pressure changes in the CHW flow distribution system.

b. Supply air temperature setpoint:

1) During occupied mode: Setpoint is reset from T-min (53°F) when the outdoor air temperature is 60°F and above, proportionally up to T-max when the outdoor air temperature is 55°F and below. T-max shall range from 55°F to 65°F and shall be the output of a slow reverse-acting PID loop that maintains the Cooling Loop of the zone served by the system with the highest Cooling Loop at a setpoint of 90%. [Note: this reset logic is preliminary; consult Engineer prior to programming.]

2) During setup or cool-down modes, the setpoint shall be T-min.
c. Supply air temperature shall be controlled to setpoint using a PID loop whose output is mapped to sequence the hot water valve, outdoor damper, return air damper, and software point CHW-Demand as shown in the diagram below. Outdoor air and return air dampers are sequenced rather than complementary (as per most standard sequences) to reduce fan power at part loads. Outdoor air and return air damper minimum and maximum positions are limited for economizer lockout and to maintain minimum outdoor airflow rate as indicated below.

d. Economizer lockout: When the outdoor air temperature falls less than the return air temperature by more than 3°F, set MaxOA-P to 100%, wait 15 seconds, then set MinRA-P to 0%. When the outdoor air temperature rises above the return air temperature, set MinRA-P to MaxRA-P, wait 15 seconds, then set MaxOA-P to MinOA-P. See minimum outdoor air control below for minimum outdoor air and maximum return air damper setpoints.

e. Freeze protection.

1) If the supply air temperature drops below 4.4°C (40°F) for 5 minutes, send two (or more, as required to ensure that heating plant is active) Boiler Plant Requests, override the outdoor air damper to the minimum position and modulate the heating coil to maintain a supply air temperature of at least 5.6°C (42°F). Disable this function when supply air temperature rises above 7.2°C (45°F) for 5 minutes.

2) If the supply air temperature drops below 3.3°C (38°F) for 5 minutes, fully close both the economizer damper and the minimum outdoor air damper for one hour, and set a Level 3 alarm noting
that minimum ventilation was interrupted. After one hour, the unit shall resume minimum outdoor air ventilation and enter the previous stage of freeze protection (see Item 1 above).

3) Upon signal from the freezestat (if installed) or if supply air temperature drops below 3.3°C (38°F) for 15 minutes or below 1.1°C (34°F) for 5 minutes, shut down supply and return/relief fan(s), close outdoor air damper, open the cooling coil valve to 100%, and energize the chilled water pump system. Also, send two (or more, as required to ensure that heating plant is active) Boiler Plant Requests, modulate the heating coil to maintain the higher of the supply air temperature or the mixed air temperature at 27°C (80°F), and set a Level 2 alarm indicating the unit is shut down by freeze protection.

   a) If a freeze protection shutdown is triggered by a low air temperature sensor reading, it shall remain in effect until it is reset by a software switch from the operator’s workstation. (If a freeze stat with a physical reset switch is used instead, there shall be no software reset switch.)

4. Minimum outdoor air control

a. Minimum outdoor airflow setpoint

1) The (AbsMin) absolute minimum outdoor air rate shall be the sum of all VAV zones minimum volume setpoints that are in the Occupied Mode, but no larger than 30% of the design cooling fan air flow rate.

2) When the AHU is in Occupied Mode and supply fan is proven on, the minimum outdoor airflow rate, MinOA, shall be AbsMin when the largest zone CO₂ control loop signal is 50% and proportionally up to 13,500 cfm when the largest zone CO₂ control loop signal is 100%. Otherwise, MinOA shall be zero.

b. Minimum outdoor air control loop

1) Minimum outdoor air control loop is enabled when the AHU is in occupied mode and disabled and output set to zero otherwise.

2) The outdoor airflow rate shall be maintained at the minimum outdoor air setpoint MinOA by a reverse-acting PID loop whose output is mapped to minimum outdoor air damper signal, MinOA-P, and maximum return air damper signal, MaxRA-P, as indicated in the figure below.
5. Economizer Relief:
   a. Relief system (Building Pressure PID) shall be enabled when the associated supply fan is proven on.
   b. The Internal AHU airflow/fan modulation control shall perform calculations and stage the fans and/or modulate the fan speed to maintain the duct static pressure set point.
   c. Building static pressure shall be time averaged with a sliding 5 minute window (to damper fluctuations). The averaged value shall be that displayed and used for control.
   d. A P-only control loop maintains the building pressure at a setpoint of 0.05 inches with an output ranging from 0 to 100%. The loop is disabled and output set to zero when all fans in the relief system group are disabled.

6. Heating supply air temperature control
   a. Heating supply air temperature control loop is enabled when the heating supply air fan is proven on, and disabled and output set to zero otherwise. When loop is disabled, slowly reduce loop output to zero to prevent sudden pressure changes in the HW flow distribution system.
   b. Supply air temperature setpoint:
      1) During Occupied Mode: Setpoint shall be reset using Trim & Respond logic [TBD] between 21°C (70°F) and Max_SAT. See 3.1E.1 for Max_SAT.
### Variable Value

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Device</td>
<td>Heating Supply Fan</td>
</tr>
<tr>
<td>SP0</td>
<td>SPmax</td>
</tr>
<tr>
<td>SPmin</td>
<td>21°C (70°F)</td>
</tr>
<tr>
<td>SPmax</td>
<td>Max_SAT</td>
</tr>
<tr>
<td>Td</td>
<td>10 minutes</td>
</tr>
<tr>
<td>T</td>
<td>2 minutes</td>
</tr>
<tr>
<td>I</td>
<td>2</td>
</tr>
<tr>
<td>R</td>
<td>Zone Heating SAT Requests</td>
</tr>
<tr>
<td>SPtrim</td>
<td>-0.22°C (-0.4°F)</td>
</tr>
<tr>
<td>SPres</td>
<td>+0.33°C (+0.6°F)</td>
</tr>
<tr>
<td>SPres-max</td>
<td>+0.78°C (+1.4°F)</td>
</tr>
</tbody>
</table>

2) During Warmup and Setback Modes: Setpoint shall be Max_SAT

3) During setback and warm-up, the setpoint shall be 95°F.

c. Supply air temperature shall be maintained at setpoint by a PID loop modulating the heating coil hot water valve.

7. Alarms (individually for heating and cooling fans, where applicable):

a. Maintenance interval alarm when fan has operated for more than 1500 hours: Level 5. Reset interval counter when alarm is acknowledged.

b. Fan alarm is indicated by the status input being different from the output command after a period of 60 seconds after a change in output status.

1) Commanded on, status off: Level 2.

2) Commanded off, status on: Level 4.

c. Filter pressure drop exceeds alarm limit. Level 5. The alarm limit shall vary with fan speed as follows:

\[
DP_x = DP_{100} \left(\frac{x}{100}\right)^{1.4}
\]

where \(DP_{100}\) is the high limit pressure drop at design cfm (determine limit from filter manufacturer) and \(DP_x\) is the high limit at blade angle signal \(x\) (expressed as a fraction of full signal). For instance, the setpoint at 50% of full blade angle would be \((.5)^{1.4}\) or 38% of the design high limit pressure drop.

d. High supply air temperature (> 3°F above setpoint) off cooling coils when coil control loop is active for longer than 5 minutes. Level 3.
e. Low supply air temperature (< 3°F below setpoint) off heating coils when coil control loop is active for longer than 5 minutes. Level 2.

f. While heating valve is closed, if the temperature increase across the heating coil exceeds 2°F continuously for 30 minutes; or if the discharge temperature is more than 5°F above setpoint for more than 30 minutes continuously: Level 4 indicating possibly leaking valve.

g. While CHW-Demand = 0, if the temperature drop across the cooling coil exceeds 2°F continuously for 30 minutes; or if the discharge temperature is more than 5°F below setpoint for more than 30 minutes continuously: Level 4 indicating possibly leaking valve.

h. If mixed air temperature is less than 40°F or greater than 85°F; OR if the outside air temperature is above the supply air temperature setpoint and the economizer is enabled and the mixed air temperature is more than 2°F different from the outside air temperature for more than 30 minutes continuously; OR if the outdoor air temperature is more than 5°F below the supply air temperature setpoint and the chilled water valve is open (or compressors are on): Level 4 indicating economizer damper control problems.

i. Low static pressure (> 0.2” below setpoint) when fan control loop is active for longer than 5 minutes. Level 2.

j. Outdoor airflow less than setpoint for 10 minutes: Level 2.

k. High building static (> 0.05” above setpoint for longer than 10 minutes.) Level 3.

l. Low building static (< 0.05” below setpoint for longer than 10 minutes.) Level 3.

8. Automatic Fault Detection and Diagnostics

a. AFDD conditions are evaluated continuously and separately for each operating air handling unit.

b. The Operating State (OS) of each AHU shall be defined by the commanded positions of the heating coil control valve, cooling coil control valve, and economizer damper in accordance with the following table and corresponding graphic.
The following points must be available to the AFDD routines for each AHU:

1) SAT = Supply air temperature
2) MAT = Mixed air temperature
3) RAT = Return air temperature
4) OAT = Outdoor air temperature
5) DSP = Duct static pressure
6) SATSP = supply air temperature setpoint
7) DSPSP = duct static pressure setpoint
8) HC = heating coil valve position command; 0% ≤ HC ≤ 100%
9) CC = cooling coil valve position command; 0% ≤ CC ≤ 100%
10) FS = fan speed command; 0% ≤ FS ≤ 100%
11) CCET = cooling coil entering temperature; depending on the AHU configuration, this could be the MAT or a separate sensor for this specific purpose.
12) CCLT = cooling coil leaving temperature; depending on the AHU configuration, this could be the SAT or a separate sensor for this specific purpose.
13) HCET = heating coil entering temperature; depending on the AHU configuration, this could be the MAT or a separate sensor for this specific purpose.
14) HCLT = heating coil leaving temperature; depending on the AHU configuration, this could be the SAT or a separate sensor for this specific purpose.

c. The following values must be continuously calculated by the AFDD routines for each AHU:
1) 5-minute rolling averages with 1-minute sampling time of the following point values; operator shall have the ability to adjust the averaging window and sampling period for each point independently.

 a) SATAVG = rolling average of supply air temperature
 b) MATAVG = rolling average of mixed air temperature
 c) RATAVG = rolling average of return air temperature
 d) OATAVG = rolling average of outdoor air temperature
 e) DSPAVG = rolling average of duct static pressure
 f) CCETAVG = rolling average of cooling coil entering temperature
 g) CCLTAVG = rolling average of cooling coil leaving temperature
 h) HCETAVG = rolling average of heating coil entering temperature
i) \( HCLTAVG = \) rolling average of heating coil leaving temperature

2) \( %OA = \) actual outdoor air fraction as a percentage \( = \frac{MAT - RAT}{OAT - RAT} \) or per airflow

3) \( %OAMIN = \) Active minimum OA setpoint (MinOAsp) divided by actual total airflow (from sum of VAV box flows, or by airflow measurement station) as a percentage.

4) \( \Delta OS = \) number of changes in Operating State during the previous 60 minutes (moving window).

d. The following internal variables shall be defined for each AHU. All parameters are adjustable by the operator, with initial values as given below:

<table>
<thead>
<tr>
<th>Variable Name</th>
<th>Description</th>
<th>Default Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \theta TSF )</td>
<td>Temperature rise across supply fan</td>
<td>1.1°C (2°F)</td>
</tr>
<tr>
<td>( \theta TMIN )</td>
<td>Minimum difference between OAT and RAT to evaluate economizer error conditions (FC#6)</td>
<td>5.6°C (10°F)</td>
</tr>
<tr>
<td>( \varepsilon SAT )</td>
<td>Temperature error threshold for SAT sensor</td>
<td>1.1°C (2°F)</td>
</tr>
<tr>
<td>( \varepsilon RAT )</td>
<td>Temperature error threshold for RAT sensor</td>
<td>1.1°C (2°F)</td>
</tr>
<tr>
<td>( \varepsilon MAT )</td>
<td>Temperature error threshold for MAT sensor</td>
<td>2.7°C (5°F)</td>
</tr>
<tr>
<td>( \varepsilon OAT )</td>
<td>Temperature error threshold for OAT sensor</td>
<td>1.1°C (2°F) if local sensor @ unit. 2.7°C (5°F) if global sensor.</td>
</tr>
<tr>
<td>( \varepsilon F )</td>
<td>Airflow error threshold</td>
<td>30%</td>
</tr>
<tr>
<td>( \varepsilon VFDS PD )</td>
<td>VFD speed error threshold</td>
<td>5%</td>
</tr>
<tr>
<td>( \varepsilon DSP )</td>
<td>Duct static pressure error threshold</td>
<td>25 Pa (0.1”)</td>
</tr>
<tr>
<td>( \varepsilon CCET )</td>
<td>Cooling coil entering temperature sensor error. Equal to ( \varepsilon MAT ) or dedicated sensor error</td>
<td></td>
</tr>
<tr>
<td>( \varepsilon CCLT )</td>
<td>Cooling coil leaving temperature sensor error. Equal to ( \varepsilon SAT ) or dedicated sensor error</td>
<td>Varies, see Description</td>
</tr>
<tr>
<td>( \varepsilon HCET )</td>
<td>Heating coil entering temperature sensor error; equal to ( \varepsilon MAT ) or dedicated sensor error</td>
<td></td>
</tr>
<tr>
<td>Parameter</td>
<td>Description</td>
<td>Value</td>
</tr>
<tr>
<td>---------------</td>
<td>------------------------------------------------------------------------------</td>
<td>-------</td>
</tr>
<tr>
<td>( \Delta HCLT )</td>
<td>Heating coil leaving temperature sensor error. Equal to ( \Delta SAT ) or dedicated sensor error.</td>
<td></td>
</tr>
<tr>
<td>OSMAX</td>
<td>Maximum number of changes in Operating State during the previous 60 minutes (moving window)</td>
<td>7</td>
</tr>
<tr>
<td>ModeDelay</td>
<td>Time in minutes to suspend Fault Condition evaluation after a change in Mode</td>
<td>30</td>
</tr>
<tr>
<td>AlarmDelay</td>
<td>Time in minutes to that a Fault Condition must persist before triggering an alarm</td>
<td>30</td>
</tr>
<tr>
<td>TestModeDelay</td>
<td>Time in minutes that Test Mode is enabled</td>
<td>120</td>
</tr>
</tbody>
</table>

e. The following are potential Fault Conditions that can be evaluated by the AFDD routines. If the equation statement is true, then the specified fault condition exists. The Fault Conditions to be evaluated at any given time will depend on the Operating State of the AHU.
<table>
<thead>
<tr>
<th>FC#1</th>
<th>Equation</th>
<th>DSP &lt; DSPSP - $\epsilon_{DSP}$ and VFDSPD $\geq$ 99% - $\epsilon_{VFDSPD}$</th>
<th>Description</th>
<th>Duct static pressure is too low with fan at full speed</th>
<th>Possible Diagnosis</th>
<th>Mechanical problem with fan</th>
<th>Fan undersized</th>
<th>SAT Setpoint too high (too much zone demand)</th>
<th>Applies to OS</th>
<th>#1 – #5</th>
</tr>
</thead>
<tbody>
<tr>
<td>FC#2</td>
<td>Equation</td>
<td>$MAT_{AVG} + \epsilon_{MAT} &lt; \min[(RAT_{AVG} - \epsilon_{RAT}), (OAT_{AVG} - \epsilon_{OAT})]$</td>
<td>Description</td>
<td>MAT too low; should be between OAT and RAT</td>
<td>Possible Diagnosis</td>
<td>RAT sensor error</td>
<td>MAT sensor error</td>
<td>OAT sensor error</td>
<td>Applies to OS</td>
<td>#1 – #5</td>
</tr>
<tr>
<td>FC#3</td>
<td>Equation</td>
<td>$MAT_{AVG} - \epsilon_{MAT} &gt; \max[(RAT_{AVG} + \epsilon_{RAT}), (OAT_{AVG} + \epsilon_{OAT})]$</td>
<td>Description</td>
<td>MAT too high; should be between OAT and RAT</td>
<td>Possible Diagnosis</td>
<td>RAT sensor error</td>
<td>MAT sensor error</td>
<td>OAT sensor error</td>
<td>Applies to OS</td>
<td>#1 – #5</td>
</tr>
<tr>
<td>FC#4</td>
<td>Equation</td>
<td>$\Delta OS &gt; \Delta OS_{MAX}$</td>
<td>Description</td>
<td>Too many changes in Operating State</td>
<td>Possible Diagnosis</td>
<td>Unstable control due to poorly tuned loop or mechanical problem</td>
<td>Applies to OS</td>
<td>#1 – #5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FC#5</td>
<td>Equation</td>
<td>$SAT_{AVG} + \epsilon_{SAT} \leq MAT_{AVG} - \epsilon_{MAT} + \Delta T_{SF}$</td>
<td>Description</td>
<td>SAT too low; should be higher than MAT</td>
<td>Possible Diagnosis</td>
<td>SAT sensor error</td>
<td>MAT sensor error</td>
<td>Cooling coil valve leaking or stuck open</td>
<td>Heating coil valve stuck closed or actuator failure</td>
<td>Fouled or undersized heating coil</td>
</tr>
</tbody>
</table>

(omit if no MAT sensor)
### Contra Costa Community College District

**BUILDING AUTOMATION SYSTEM**

**Section 25 00 00 – Page 175**

- C-1129 PAC Boiler Replacement
- C-1130 PAC Chiller Replacement
- C-1131 AT Packaged Unit Replacement
- D-1044 Campus-Wide EMS Upgrades
- D-4017 Mechanical Equipment Retrofit
- P-4022 AHU Replacement

---

<table>
<thead>
<tr>
<th>FC#6</th>
<th>Description</th>
<th>Equation</th>
<th>Diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OA fraction is too low or too high; should equal %OA_MIN</td>
<td>$</td>
<td>\text{RAT}<em>{\text{AVG}} - \text{OAT}</em>{\text{AVG}}</td>
</tr>
</tbody>
</table>

Applies to OS #1, #4

<table>
<thead>
<tr>
<th>FC#7</th>
<th>Description</th>
<th>Equation</th>
<th>Diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SAT too low in full heating</td>
<td>SAT_{AVG} &lt; SATSP - \varepsilon_{SAT}$ and $HC \geq 99%$</td>
<td>SAT sensor error Possible Cooling coil valve leaking or stuck open Heating coil valve stuck closed or actuator failure Fouled or undersized heating coil HW temperature too low or HW unavailable Leaking or stuck economizer damper or actuator</td>
</tr>
</tbody>
</table>

Applies to OS #1

<table>
<thead>
<tr>
<th>FC#8</th>
<th>Description</th>
<th>Equation</th>
<th>Diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SAT and MAT should be approximately equal</td>
<td>$</td>
<td>SAT_{AVG} - \Delta T_{SF} - MAT_{AVG}</td>
</tr>
</tbody>
</table>

Applies to OS #2

<table>
<thead>
<tr>
<th>FC#9</th>
<th>Description</th>
<th>Equation</th>
<th>Diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OAT is too high for free cooling without additional mechanical cooling</td>
<td>$OAT_{AVG} - \varepsilon_{\text{OAT}} &gt; SATSP - \Delta T_{SF} + \varepsilon_{\text{SAT}}$</td>
<td>SAT sensor error OAT sensor error Cooling coil valve leaking or stuck open</td>
</tr>
</tbody>
</table>

Applies to OS #2
<table>
<thead>
<tr>
<th>FC#</th>
<th>Equation</th>
<th>Description</th>
<th>Possible Diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>FC#10</td>
<td>[</td>
<td></td>
<td>OAT and MAT should be approximately equal</td>
</tr>
<tr>
<td></td>
<td>MAT \text{avg} - OAT \text{avg}</td>
<td>MAT sensor error</td>
<td></td>
</tr>
<tr>
<td></td>
<td>] &gt; J \varepsilon_{\text{MAT}}^2 + \varepsilon_{\text{OAT}}^2</td>
<td>OAT sensor error</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Applies to OS #3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FC#11</td>
<td>OAT \text{avg} + \varepsilon_{\text{OAT}} &lt; \text{SATSP} - \Delta T_{\text{SF}} - \varepsilon_{\text{SAT}}</td>
<td>OAT too low for 100% OA cooling</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SAT sensor error</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>OAT sensor error</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Applies to OS #3</td>
<td>Heating coil valve leaking or stuck open</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Leaking or stuck economizer damper or actuator</td>
<td></td>
</tr>
<tr>
<td>FC#12</td>
<td>SAT \text{avg} - SAT_{\text{SP}} - \Delta T_{\text{SF}} \geq MAT_{\text{avg}} + \varepsilon_{\text{MAT}}</td>
<td>SAT too high; should be less than MAT</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SAT sensor error</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>MAT sensor error</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Applies to OS #3, #4</td>
<td>Cooling coil valve stuck closed or actuator failure</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fouled or undersized cooling coil</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>CHW temperature too high or CHW unavailable</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Heating coil valve leaking or stuck open</td>
<td></td>
</tr>
<tr>
<td>FC#13</td>
<td>SAT_{\text{avg}} &gt; \text{SATSP} + \varepsilon_{\text{SAT}} \text{ and } CC \geq 99%</td>
<td>SAT too high in full cooling</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SAT sensor error</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cooling coil valve stuck closed or actuator failure</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fouled or undersized cooling coil</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CHW temperature too high or CHW unavailable</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Heating coil valve leaking or stuck open</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Applies to OS #3, #4</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**FC#14**  
**Equation**  
\[ \text{CCET}_{avg} - \text{CCLT}_{avg} \geq J\varepsilon_{\text{CCET}}^2 + \varepsilon_{\text{CCLT}}^2 + \Delta T_{sf} \]  
*Fan heat factor included or not depending on location of sensors used for CCET and CCLT*

<table>
<thead>
<tr>
<th><strong>Description</strong></th>
<th>Temperature drop across inactive cooling coil</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Possible Diagnosis</strong></td>
<td>CCET sensor error, CCLT sensor error, Cooling coil valve stuck open or leaking.</td>
</tr>
</tbody>
</table>

**FC#15**  
**Equation**  
\[ \text{HCLT}_{avg} - \text{HCET}_{avg} \geq J\varepsilon_{\text{HCET}}^2 + \varepsilon_{\text{HCLT}}^2 + \Delta T_{sf} \]  
*Fan heat factor included or not depending on location of sensors used for HCET and HCLT*

<table>
<thead>
<tr>
<th><strong>Description</strong></th>
<th>Temperature rise across inactive heating coil</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Possible Diagnosis</strong></td>
<td>HCET sensor error, HCLT sensor error, Heating coil valve stuck open or leaking.</td>
</tr>
</tbody>
</table>

**f.** A subset of all potential fault conditions is evaluated by the AFDD routines. The set of applicable fault conditions depends on the Operating State of the AHU:

1) In OS #1 (Heating), the following Fault Conditions shall be evaluated:

a) FC#1: Duct static pressure is too low with fan at full speed
b) FC#2: MAT too low; should be between RAT and OAT
c) FC#3: MAT too high; should be between RAT and OAT
d) FC#4: Too many changes in Operating State
e) FC#5: SAT too low; should be higher than MAT
f) FC#6: OA fraction is too low or too high; should equal %OAMIN
g) FC#7: SAT too low in full heating
h) FC#14: Temperature drop across inactive cooling coil
2) In OS#2 (Modulating Economizer), the following Fault Conditions shall be evaluated:
   a) FC#1: Duct static pressure is too low with fan at full speed
   b) FC#2: MAT too low; should be between RAT and OAT
   c) FC#3: MAT too high; should be between RAT and OAT
   d) FC#4: Too many changes in Operating State
   e) FC#8: SAT and MAT should be approximately equal
   f) FC#9: OAT is too high for free cooling without mechanical cooling
   g) FC#14: Temperature drop across inactive cooling coil
   h) FC#15: Temperature rise across inactive heating coil

3) In OS#3 (Mechanical + 100% Economizer Cooling), the following Fault Conditions shall be evaluated:
   a) FC#1: Duct static pressure is too low with fan at full speed
   b) FC#2: MAT too low; should be between RAT and OAT
   c) FC#3: MAT too high; should be between RAT and OAT
   d) FC#4: Too many changes in Operating State
   e) FC#10: OAT and MAT should be approximately equal
   f) FC#11: OAT too low for 100% OA
   g) FC#12: SAT too high; should be less than MAT
   h) FC#13: SAT too high in full cooling
   i) FC#15: Temperature rise across inactive heating coil

4) In OS#4 (Mechanical Cooling, Min OA), the following Fault Conditions shall be evaluated:
   a) FC#1: Duct static pressure is too low with fan at full speed
   b) FC#2: MAT too low; should be between RAT and OAT
   c) FC#3: MAT too high; should be between RAT and OAT
d) FC#4: Too many changes in Operating State

e) FC#6: OA fraction is too low or too high; should equal %OAMIN

f) FC#12: SAT too high; should be less than MAT

g) FC#13: SAT too high in full cooling

h) FC#15: Temperature rise across inactive heating coil

5) In OS#5 (Other), the following Fault Conditions shall be evaluated:

a) FC#1: Duct static pressure is too low with fan at full speed

b) FC#2: MAT too low; should be between RAT and OAT

c) FC#3: MAT too high; should be between RAT and OAT

d) FC#4: Too many changes in Operating State

g. For each air handler, the operator shall be able to suppress the alarm for any Fault Condition.

h. Evaluation of Fault Conditions shall be suspended under the following conditions:

1) When AHU is not operating.

2) For a period of ModeDelay minutes following a change in Mode (e.g., from Warm up to Occupied) of any Zone Group served by the AHU.

i. Fault Conditions that are not applicable to the current Operating State shall not be evaluated.

j. A Fault Condition that evaluates as true must do so continuously for AlarmDelay minutes before it is reported to the operator.

k. Test Mode shall temporarily set ModeDelay and AlarmDelay to 0 minutes for a period of TestModeDelay minutes to allow instant testing of the AFDD system and ensure normal fault detection occurs after testing is complete.

l. When a Fault Condition is reported to the operator, it shall be a Level 3 alarm and shall include the description of the fault and the list of possible diagnoses from the table in 5.14M.6.

9. Automatic Fault Detection and Diagnostics for the Hot Deck Air Handling Unit:
a. AFDD conditions are evaluated continuously and separately for each operating air handling unit.

b. The following points must be available to the AFDD routines for each AHU:
   1) SAT = Supply air temperature
   2) RAT = Return air temperature
   3) DSP = Duct static pressure
   4) SATSP = supply air temperature setpoint
   5) DSPSP = duct static pressure setpoint
   6) HC = heating coil valve position command; 0% ≤ HC ≤ 100%
   7) FS = fan speed command; 0% ≤ FS ≤ 100%

c. The following values must be continuously calculated by the AFDD routines for each AHU:
   1) 5-minute rolling averages with 1-minute sampling time of the following point values; operator shall have the ability to adjust the averaging window and sampling period for each point independently
      a) SATAVG = rolling average of supply air temperature
      b) RATAVG = rolling average of return air temperature
      c) DSPAVG = rolling average of duct static pressure

d. The following internal variables shall be defined for each AHU. All parameters are adjustable by the operator, with initial values as given below:
<table>
<thead>
<tr>
<th>Variable Name</th>
<th>Description</th>
<th>Default Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>△TSF</td>
<td>Temperature rise across supply fan</td>
<td>1.1°C (2° F)</td>
</tr>
<tr>
<td>ƐSAT</td>
<td>Temperature error threshold for SAT sensor</td>
<td>1.1°C (2° F)</td>
</tr>
<tr>
<td>ƐRAT</td>
<td>Temperature error threshold for RAT sensor</td>
<td>1.1°C (2° F)</td>
</tr>
<tr>
<td>ƐVFDSPD</td>
<td>VFD speed error threshold</td>
<td>5%</td>
</tr>
<tr>
<td>ƐDSP</td>
<td>Duct static pressure error threshold</td>
<td>25 Pa (0.1&quot;)</td>
</tr>
<tr>
<td>ModeDelay</td>
<td>Time in minutes to suspend Fault Condition evaluation after a change in Mode</td>
<td>30</td>
</tr>
<tr>
<td>AlarmDelay</td>
<td>Time in minutes to that Fault Condition must persist before triggering an alarm</td>
<td>30</td>
</tr>
<tr>
<td>TestModeDelay</td>
<td>Time in minutes that Test Mode is enabled</td>
<td>120</td>
</tr>
</tbody>
</table>

e. The following are potential Fault Conditions that can be evaluated by the AFDD routines. If the equation statement is true, then the specified fault condition exists.

10. The following are potential Fault Conditions that can be evaluated by the AFDD routines. If the equation statement is true, then the specified fault condition exists.
<table>
<thead>
<tr>
<th>FC#1</th>
<th>Equation</th>
<th>Description</th>
<th>Possible Diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[ \text{DSP} &lt; \text{DSP}<em>{\text{SP}} - \varepsilon</em>{\text{DSP}} ] \text{ and } [ \text{VFDSPD} \geq 99% - \varepsilon_{\text{VFDSPD}} ]</td>
<td>Duct static pressure is too low with fan at full speed</td>
<td>Problem with VFD Mechanical system, fan undersized, SAT Setpoint too high (too much zone demand)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FC#2</th>
<th>Equation</th>
<th>Description</th>
<th>Possible Diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[ \text{SAT}<em>{\text{AVG}} &lt; \text{SAT}</em>{\text{SP}} - \varepsilon_{\text{SAT}} ] \text{ and } [ \text{HC} \geq 99% ]</td>
<td>SAT too low in full heating</td>
<td>Heating coil valve stuck closed or actuator failure, Fouled or undersized heating coil, HW temperature too low or HW unavailable</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FC#3</th>
<th>Equation</th>
<th>Description</th>
<th>Possible Diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[ \text{RAT}<em>{\text{AVG}} - \text{SAT}</em>{\text{AVG}} \geq \text{J} \varepsilon_{\text{SAT}}^2 + \varepsilon_{\text{RAT}}^2 + \Delta T_{\text{SF}} ] \text{ and } [ \text{HC} = 0% ]</td>
<td>Temperature rise across inactive heating coil</td>
<td>HCET sensor error, HCLT sensor error, Heating coil valve stuck open or leaking.</td>
</tr>
</tbody>
</table>

11. For each air handler, the operator shall be able to suppress the alarm for any Fault Condition.

12. Evaluation of Fault Conditions shall be suspended under the following conditions:
   a. For each air handler, the operator shall be able to suppress the alarm for any Fault Condition.
b. Evaluation of Fault Conditions shall be suspended under the following conditions:

1) When AHU is not operating.

2) For a period of ModeDelay minutes following a change in Mode (e.g., from Warm up to Occupied) of any Zone Group served by the AHU.

c. A Fault Condition that evaluates as true must do so continuously for AlarmDelay minutes before it is reported to the operator.

d. Test Mode shall temporarily set ModeDelay and AlarmDelay to 0 minutes for a period of TestModeDelay minutes to allow instant testing of the AFDD system and ensure normal fault detection occurs after testing is complete.

e. When a Fault Condition is reported to the operator, it shall be a Level 3 alarm and shall include the description of the fault and the list of possible diagnoses from the table in TBD.

f. Testing/Commissioning Overrides: Provide software switches that interlock to a chilled water and hot water plant level to:

1) If there is a hot water coil, force hot water valve full open

2) If there is a hot water coil, force hot water valve full closed

3) Force chilled water valve full open

4) Force chilled water valve full closed

13. Plant Request (Implement this sequences to the existing chilled and hot water plant).

a. Chilled Water Reset Requests

1) If the supply air temperature exceeds the supply air temperature setpoint by 2.8°C (5°F) for 2 minutes, send 3 Requests,

2) Else if the supply air temperature exceeds the supply air temperature setpoint by 1.7°C (3°F) for 2 minutes, send 2 Requests,

3) Else if the CHW valve position is greater than 95%, send 1 Request until the CHW valve position is less than 85%,

4) Else if the CHW valve position is less than 95%, send 0 Requests.
b. Chiller Plant Requests. Send the chiller plant that serves the system a Chiller Plant Request as follows:

1) If the CHW valve position is greater than 95%, send 1 Request until the CHW valve position is less than 10%,

2) Else if the CHW valve position is less than 95%, send 0 Requests.

c. If there is a hot water coil, Hot Water Reset Requests

1) If the supply air temperature is 17°C (30°F) less than setpoint for 5 minutes, send 3 Requests,

2) Else if the supply air temperature is 8.3°C (15°F) less than setpoint for 5 minutes, send 2 Requests,

3) Else if HW valve position is greater than 95%, send 1 Request until the HW valve position is less than 85%,

4) Else if the HW valve position is less than 95%, send 0 Requests

d. If there is a hot water coil, Boiler Plant Requests. Send the boiler plant that serves the AHU a Boiler Plant Request as follows:

1) If the HW valve position is greater than 95%, send 1 Request until the HW valve position is less than 10%,

2) Else if the HW valve position is less than 95%, send 0 Requests.

END OF SECTION
FIELD TEST AND OPERATIONAL CHECK

SECTION 26 01 26

FIELD TEST AND OPERATIONAL CHECK

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Ground resistance test.

B. Electrical tests - circuit protective devices.

C. Operational check of distribution panels, and panelboards.

D. Operational check of selected combination starters.

E. Testing of transformers.

F. Ground fault system test.

1.02 QUALITY ASSURANCE


B. Provide services for the purpose of performing inspections and tests as herein specified.

C. Provide all material, equipment, labor and technical supervision to perform such tests and inspections.

D. Assure that all electrical equipment, both Design Builder and Owner-supplied, is operational within industry and manufacturer's tolerances and is installed in accordance with contract specifications.

E. The tests and inspections outlined in this section, together with specific testing required in other sections shall determine the suitability for energization.

1.03 TEST INSTRUMENT TRACEABILITY

A. All instruments shall be included in a calibration program which maintains all applicable test instrumentation within rated accuracy.

B. Instruments shall be calibrated in accordance with the following frequency schedule:

1. Field instruments: 6 months maximum.

2. Laboratory Instruments: 12 months.
3. Leased specialty equipment: 12 months. (Where accuracy is guaranteed by lessor).

C. Dated calibration labels shall be visible on all test equipment.

1.04 FINAL SETTINGS:

A. The Design Builder shall be responsible for implementing all final settings and adjustments on protective devices and tap changers in accordance with specified values.

1.05 TEST REPORTS:

A. The test reports shall include the following:

1. Summary of project.
2. Description of equipment tested.
3. Description of test.
4. List of test equipment used in calibration and calibration date.
5. Test results.
6. Test results and settings of all adjustable devices.
7. Appendix, including appropriate test forms.

B. The test reports shall be bound and its contents certified by the Design Builder.

C. Submit 4 copies of the completed report simultaneously to the Owner no later than fifteen days after completion of test unless directed otherwise.

1.06 FAILURE TO MEET TEST:

A. Any system, material or workmanship which is found defective on the basis of acceptance tests shall be reported directly to the Owner.

B. Design Builder shall replace the defective material or equipment and have test repeated until test proves satisfactory without additional cost to the Owner.

PART 2 - PRODUCTS – NOT USED

PART 3 - EXECUTION

3.01 GROUND RESISTANCE TEST

A. Test ground rods for ground resistance value before any wire is connected. Measure ground resistance to earth for each ground rod utilizing the fall of potential method. A
portable ground testing megger shall be used to test each ground. The instruments shall be equipped with a meter reading directly in ohms or fractions thereof to indicate the ground value of the ground electrode under test. Provide the Owner one copy of the megger manufacturer's directions for use of the ground megger indicating the method to be used, and the results for each ground rod.

3.02 ELECTRICAL TESTS - CIRCUIT PROTECTIVE DEVICES

A. Molded Case Circuit Breakers.
   1. Visual and Mechanical Inspection:
      a. Check circuit breakers for proper mounting and compare nameplate data to drawings and specifications.
      b. Operate circuit breakers to ensure smooth operation.
      c. Inspect case for cracks or other defects.
      d. Check tightness of connections using calibrated torque wrench. Conform to manufacturer's recommendations and instructions.
   2. Electrical Tests:
      a. Prior to energization of overcurrent protective devices, test devices for continuity of circuitry and short circuits. Correct malfunctioning units, and demonstrate compliance with requirements.
      b. Test operation of shunt trip breakers by operating emergency power control station(s).

3.03 OPERATIONAL CHECK OF DISTRIBUTION PANELS, AND PANELBOARDS

A. Check that schedules, nameplates, identification and markings are correct and in place.
B. Check cleanliness of all interiors all parts. Remove any excess packing, shipping bolts, wire and insulation debris, etc.
C. Tighten all points of connection with torque wrench in accordance with manufacturer's specified values.
D. Check calibration of all meters at zero, mid-scale and full-scale deflections by transfer standard.
E. Verify all instrument multipliers and scale factors.
F. If any equipment is found to be defective during operational check, it shall be replaced by the Design Builder with no additional cost to the Owner.
3.04 COMBINATION MOTOR STARTER OPERATIONAL CHECK

   A. Check operation of combination motor starters, and verify heater (over-current) size for motor protection.

3.05 TRANSFORMERS

   A. Verify and change, if necessary, all tap settings of all transformers to proper secondary voltages of nominal: 277/480V and 120/208V. Secondary voltages must be measured with all lighting, receptacles, motors and equipment within the building in operating conditions.

3.06 GROUND FAULT SYSTEM TEST

   A. Test ground fault system in accordance with manufacturer's specifications. Each ground fault protection equipped device shall be performance tested in accordance with NEC Article 230 to ensure:

       1. Correct current pick-up sensitivity setting with downstream devices
       2. Correct time delay with downstream devices.

3.07 OTHER TESTS

   A. Refer to other sections of this specification for tests on other equipment or systems.

END OF SECTION
SECTION 26 05 00
COMMON WORK FOR ELECTRICAL

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. The scope of work covered by these specifications includes the complete design and installation of all electrical work for this project. This project uses a Design Build. Refer to Section 23 00 00 for Design Build Requirements. The scope includes furnishing all drawings, calculations, design, equipment, material and labor necessary for complete and operable systems, including General Conditions and Agreement for Mechanical and Control Design-Build Project.

1.02 RELATED SECTIONS

A. Documents affecting work of this Section include, but are not necessarily limited to, General Conditions, Supplementary Conditions, and the Agreement for Mechanical and Control Design-Build Project.

1. Section 260126 - Field Test and Operational Check
2. Section 260502 - Basic Materials and Methods
3. Section 260529 - Hangers, Supports, Anchors, and Seismic Restraints for Electrical Systems
4. Section 262416 - Panelboards
5. Section 262913 - Low-Voltage Motor Controllers

1.03 DESCRIPTION OF WORK

A. The work includes but is not necessarily limited to the following general headings:

1. Plan check/permit process.
2. Shop drawings and submittals.
3. Record as-built documents.
4. Operations and maintenance manuals.
5. Equipment and systems training for Owner’s personnel.
6. Testing
7. Commissioning.
8. Cutting, drilling, notching for installed systems.
9. All bases, seismic bracings, supports and hangers for installed systems.
10. See subsequent sections for detailed descriptions.

1.04 CODE COMPLIANCE AND REFERENCES

A. All work and materials shall comply with the latest adopted rules, codes and regulations, including, but not necessarily limited to:

5. National Electrical Manufacturer's Association Standards (NEMA).
6. American National Standards Institute (ANSI)
10. Occupational Safety and Health Act Standards (OSHA).
11. Institute of Electrical and Electronics Engineering Representatives (IEEE).
12. All other applicable Federal and State and local laws and regulations.

B. Compliance with code is mandatory. These drawings and Specifications do not allow work not conforming to these codes. Where work is shown to exceed minimum code requirements, comply with drawings and Specifications.

C. Give necessary notices, obtain permits, pay taxes, fees and other costs in connection with work, file necessary plans, prepare documents, and obtain necessary approvals of the authorities having jurisdiction. Obtain all required Certificates of Inspection for work and deliver to Owner's Representative before request for acceptance and final payment of work.

D. Include in the Work: labor, material, services, apparatus, drawings (in addition to Contract drawings and Documents) required to comply with applicable laws, ordinances, rules and regulations. Examples of these drawings are those required to be submitted to the Fire Marshal for approval.
E. References

1. ASTM A-36: Structural Steel Shapes and Plates.
2. ASTM A-501: Steel Tubing.
3. ASTM A-53: Steel Pipes, Grade B.

1.05 DEFINITIONS

A. "Authorities having jurisdiction" means all governmental, utility, building, and fire protection authorities having jurisdiction.

B. "Concealed" means hidden from sight in chases, furred spaces, shafts, hung ceilings, or embedded in construction.

C. "Contract Documents" means drawings and specifications.

D. "Drawings" means any drawings of the Bid Documents.

E. "Exposed" means not installed underground or "concealed" as defined above.

F. "Furnish" means to supply and deliver to the job.

G. "Or equal" means any equipment or material which, in the opinion of the Owner, is equal in quality, durability, appearance, strength, design and performance to the equipment or material specified and will function adequately in accordance with the General Design.

H. "Provide" means supply, erect, install, and connect up complete in readiness for regular operation, the particular work referred to.

I. "Wiring" includes, in addition to conductors, all raceways, conduit, fittings, boxes, switches, hangers and other accessories related to such wiring.

J. Singular Number: Where any device or part of equipment is herein referred to in the singular number, such reference shall be deemed to apply to as many such devices as are required to complete the installation or as shown.

K. Reference abbreviations and Symbols: Refer to Drawings.

1.06 DRAWINGS AND SPECIFICATIONS

A. All drawings and Divisions of these specifications shall be considered as a whole, and work of this Division shown anywhere therein shall be furnished under this Division.
Review contract documents of all Divisions and report to Owner all discrepancies between this Division and any other Division, before submitting bid. In case of conflict between the drawings and specifications or within the drawings, or within the specifications, Design Builder shall base bid on the most stringent specifications and drawings requirements of any Division, and provide work accordingly. In case of conflict between the Code and drawings or specifications, the Design Builder shall provide work that complies with Code as part of base bid. Scope of work excluded in one part of the document, but included in another part of the document shall be considered as required and included work of this Division. Use Campus Site Drawings as basis, and revise to include all new work for as built drawings.

B. Drawings are diagrammatic and indicate the general arrangement of equipment and wiring. Most direct routing of conduits and wiring shall be coordinated with other Sections and Division of this specification. Exact requirements shall be governed by architectural, structural and mechanical conditions of the job. Consult all other Sections, Divisions and drawings prior to execution of the work. Extra lengths of wiring or addition of pull or junction boxes, etc., necessitated by such conditions shall be provided as part of the work. Check all drawings, Sections, and Divisions of this specification and report, in writing, any apparent discrepancies before proceeding with the work. The most stringent requirements shown in any code, drawings, or specification Section, or Division shall be provided as part of the work, until informed to the contrary by the Owner.

C. Electrical motors, controllers, detectors, panels, switches, and other electrical devices requiring line voltage power supply shall be provided with conduits, wires, circuit breakers, and proper voltage and characteristics of that device by this Division, even though these devices or equipment are only shown on Architectural, Structural, Mechanical, Plumbing, Landscaping, Controls and drawings of other Divisions. Any electrical device or fixture shown on the drawings shall be wired based on its rating and information indicated on the documents or best arrangement as approved by the Owner Representative.

D. Should conditions require revision to space or rearrangement to suit design of equipment proposed for installation, shop drawings shall be submitted to show changes in the work. Arrange for the necessary space and revisions to work under other Divisions before proceeding with any work. Do not decrease sizes or make radical changes in the installation without written approval of the Owner. Design Builder shall be held responsible for any changes made based on incomplete information or without approval.

E. By submitting a Bid, the Design Builder represents that he has made a thorough examination of the site of the work and all existing conditions and limitations, and that he has examined all Drawings and Specifications in complete detail, and has determined beyond doubt that the drawings and specifications are sufficient, adequate, and satisfactory for the construction of the work under the contract. Any discrepancies found between the drawings and specifications shall be immediately reported in writing to the Owner for clarification. In case of conflict between the specifications and drawings or within the specifications, or within the drawings the Design Builder shall base his bid and perform the work from the most stringent specifications and drawings requirements.

F. Immediately repair or replace all utility services and installations damaged in performing work under this Division at the expense of the Design Builder causing the damage. Obtain written approval of the repair or replacement from the Owner.
G. If existing active utility services are encountered which require relocation, make request to proper authorities for procedures. Properly terminate existing services to be abandoned in conformance with requirements of authorities having jurisdiction.

H. Submit shop drawings of underground conduit routing and comply with applicable structural requirements to accommodate its installation before start of building foundation form work. Submit copy of these drawings to Owner.

1.07 RECORD DRAWINGS AND AS-BUILT DOCUMENTS

A. General: These documents shall be submitted in accordance with the requirements of Agreement for Mechanical and Control Design-Build Project.

B. Provide updated and corrected submittal to as-built conditions, including one separate set of reproducible drawings to be furnished to the Owner, after completion of all Work and before final acceptance. Include record copies of all submittal data, shop drawings, showing equipment locations, control panel layouts, complete point to point interconnection wiring diagrams, conduit routing, site underground conduit and site lighting. Use site drawings as basis, and revise to include all new works in as-built drawings.

C. Site Lighting and Underground Electrical Installation: Show on the as-built drawings the dimensions and actual location of underground conduits, power and miscellaneous systems, manholes and hand-holes, light poles, equipment, etc. Show layout, sketches and installation on same scale as contract electrical site plan drawings.

D. Building Interior Electrical Feeders and Miscellaneous Systems Conduit Installation: Show on the as-built drawings the dimensions and actual location of exposed, concealed, under building slab feeders and miscellaneous systems conduit installation including size of code required pull or junction boxes. Show layout, sketches and installation on same floor plan scale as contract electrical floor plans.

E. Lighting, Branch Circuits, Motor and Equipment Circuits, and Miscellaneous Systems: Show actual location of conduit homeruns to respective panels, terminal boards or equipment, and indicate location of conduits in slab, running up or down walls. Show these as-built drawings on same scale as electrical contract drawings.

F. Factory and field test reports for electrical equipment.

G. Protective device coordination and short circuit studies.

H. Design Builder shall bear all costs associated to provide these as-built documents, including reproductions, drafting, etc.

I. Submit two sets of black and white printed drawings and one copy of electronic files to the Owner before final acceptance. All drawings shall be on full size sheets same as the contract drawings, and submit drawings in latest revision electronic autocad files.

J. Grounding System
1. Indicate on as-Built drawings the location of all ground rods, mats, grids, building ground bus, supplementary grounding electrodes, steel building columns, and other metal structures connected to the grounding system.

2. The location of each ground rod, ground rod assembly, and other grounding electrodes shall be identified by letter in alphabetical order and keyed to the record of ground resistance tests.

1.08 GUARANTEE

A. Provide in accordance with the requirements of Agreement for Mechanical and Control Design-Build Project. See subsequent sections for additional requirements. Detective parts will be replaced at no cost to the Owner.

1.09 PRODUCT OPTIONS AND SUBSTITUTIONS

A. Submit in accordance with the requirements of Agreement for Mechanical and Control Design-Build Project.

B. Where the words "or equal" appear in these specifications, written request for substitution must be approved in writing per the Agreement for Mechanical and Control Design-Build Project.

1.10 SUBMITTALS

A. Submit shop drawings and materials lists in accordance with the requirements of Agreement for Mechanical and Control Design-Build Project.

B. All proposed deviations from specifications must be clearly listed under a heading entitled "DEVIATIONS".

C. Submit number of sets of Operating and Maintenance Manuals of equipment as specified in Agreement for Mechanical and Control Design-Build Project, or as indicated in Section specifying equipment.

1. Operations and Maintenance Data
   a. Upon completion of the work, submit operating and maintenance manuals as specified in Agreement for Mechanical and Control Design-Build Project. Include all shop drawings, instruction sheet, bulletins and all pertinent information required by the Owner for proper maintenance, operation, and adjustment of each and every piece of equipment furnished. Provide information in hard copy, one set, and in CD-ROM format, 5 copies. Do not include information which does not concern equipment actually furnished. Include information for all items mentioned under "Submittals" in subsequent section.

D. For specific requirements, see the Sections in which the equipment is specified.

E. Shop Drawings: Submit the following Drawings at 1/4" scale or larger prepared in AutoCAD 2010 format or Owner’s input.
1. Shop Drawings, equipment, cuts, catalogs or descriptive literature with complete certified characteristic of equipment, dimensions, schedules, wiring diagrams, catalog numbers, code requirements and manufacturer's requirements. Clearly delineate and show options that are provided for the equipment.

2. Resubmitted shop drawings: make corrections noted from previous submissions.

3. Work shall not proceed until Shop Drawing or sample has been reviewed and approved.

4. Include manufacturer's specifications, physical dimensions and ratings of all equipment.

5. Acceptance of materials and equipment does not relieve the Design Builder of the responsibility of not complying with the Drawings and Specifications, unless the submittal clearly states that the equipment does not agree with the Drawings and Specifications and lists the deviations in paragraph 1.9.B of this section.

6. Shop drawings shall include cable tray layout, feeder conduit runs, surface metal raceway layout and items specified in other sections of this specification.

F. Coordination Drawings: See Section 230500, "Common Work Results for HVAC." Participate with all other divisions to prepare separate coordination drawings.

G. Electrical Seismic Restraint System

1. Submit complete shop drawings showing the locations and types of all seismic bracing for equipment, conduits, busducts, and cable trays. Include a complete bill of materials for each restraint, indicating the type and size of structural attachment, brace and conduit hanger assembly.

1.11 SUBMITTAL REVIEW

A. Check and coordinate all submittals with the requirements of the work and verify all quantities, materials and related field measurements and construction criteria.

B. Review by the Owner’s Representative is only for general conformity with the design concept of the project and general compliance with the information given in the contract documents. Any action shown is subject to the requirements of the plans and specifications. No deviations from the contract documents are included in the review, unless specifically called to the attention of the Owner’s Representative by the Design Builder, and responded in writing by the Owner’s Representative. Review by the Owner’s Representative shall not relieve the Design Builder of responsibility for reviews and approvals that are required by Code authorities having jurisdiction, even if accomplished before those reviews.

C. Dimensions, quantity, finish, voltage, current, and phase are not included in the review. The Design Builder shall verify the materials supplied under all Divisions and Contract Drawings. Any additional material or cost required by an approved substitution for any specified material or work shall be borne by the Design Builder requesting the substitution. The Design Builder is not relieved from complying with the plans and
specifications or with any applicable codes and ordinances relating to his work, for the Owner Representative's notes on the submittal review.

D. Design Builder is responsible for all dimensions, which shall be confirmed and correlated at the job site, drawings and work of other Divisions, fabrication processes and techniques of construction, coordination of his work and materials with other trades, and the satisfactory performance of his work.

1.12 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Deliver, store, and handle materials in a manner to prevent damage.

B. Comply with Agreement for Mechanical and Control Design-Build Project and the following:

1. Scaffolding, Rigging and Hoisting: Provide scaffolding, rigging, hoisting, and services under this Division. Remove same from premises when no longer required.

2. Deliver materials or equipment to the project in the manufacturer's original, unopened and labeled containers. Protect the equipment and apparatus from damage caused by theft, construction debris and activities, weather, and all building operations. Failure to protect the materials and equipment adequately to the satisfaction of the Owner is sufficient cause for the rejection of any damaged materials or equipment. Close all equipment openings to prevent obstructions and damage. Do not deliver materials to the job before they are ready for installation, unless adequate security is provided.

3. Take all precautions to guard against and eliminate fire hazards in connection with the Work under this Division.

1.13 SCHEDULING

A. In addition to complying with requirements of Agreement for Mechanical and Control Design-Build Project, Construction Schedule, and other sections of this Division, Design Builder shall:

1. Mount all motors, starters, Design Builders, and other devices furnished under other Divisions.

2. Provide electrical power and wiring to all electrical appliances, equipment, devices, etc., indicated in Contract Documents, whether the item is provided under this Contract or noted as Not-In-Contract.

3. Provide separate disconnect switches for all motors (3/4 H.P. or larger) and contactors where required by code or local conditions. Provide manually operated thermal starting switches with pilot light for all fractional horsepower motors (1/2 H.P. and smaller). Provide manual control switch with pilot light for fractional horsepower motors equipped with built-in thermal protection.
4. Consult the Contract Drawings, Specifications, and Design Builders of other trades to verify the location of building components and work to be installed by other trades. Arrange the work schedule with minimum interferences with the work of other trades.

5. Consult and cooperate with other Divisions and Sections for determining space requirements and adequate clearances to other equipment in the building. Owner reserves the right to determine space priority in the event of interference between piping, conduit, and equipment of various trades.

6. Remove, relocate, and reconnect work installed that interferes with work of other trade.

7. Provide shop drawings of critical areas to demonstrate that Code clearances are met.

8. Service Disconnection and Interruption:
   a. Service Interruption: All service interruptions shall be scheduled through the Owner by providing a notice 14 working days in advance. See Agreement for Mechanical and Control Design-Build Project for other requirements.
   b. Service Disconnection: All circuits and equipment to be disconnected shall be traced by the Design Builder to ensure that vital services to other areas are not interrupted.

1.14 INSPECTION OF CONDITIONS

A. Examine related work and conditions before starting work of this Division. Report to Owner in writing of conditions which will prevent proper installation of this work. Beginning work of this Division without reporting unsuitable conditions to Owner constitutes acceptance of conditions by Design Builder. Perform required removal, repair, or replacement of this work caused by unsuitable conditions as part of the Base Bid.

B. Verify all measurements with architectural and structural drawings and at the job site and be responsible for their correctness. Design Builder shall be responsible for making a proper and thorough investigation of these requirements.

C. Inspect the site to determine receiving facilities and storage space for unloading and storing of materials, equipment, and tools.

D. The Contract is based on the drawings, and specifications, and that the Design Builder has investigated, understands, and accepts drawings and specifications and all existing conditions. No claims for extra compensation will be allowed later on account of differences between actual conditions and drawings and specifications.

E. During the Bid period; Design Builder shall visit the site of the Work, take measurements, examine all existing areas where work is to be performed and get information necessary for proper execution of the work. Ascertain, check and compare all conditions with the
Drawings and Specifications, other trades, existing conditions and where the Work is to be performed. If the Design Builder did not visit the site, investigate, and compare the conditions with the drawing and specifications; Design Builder will not be given additional money for work he may claim later because the existing condition are different with the drawings and specifications. Where revisions or changes in the existing work are required to permit the installation or new work, they shall be made as part of the work; no allowance shall be subsequently made for error or omission by the Bidder in this connection.

1.15 COORDINATION

A. Coordination Drawings

1. Furnish layout of electrical work that requires coordination with other Divisions and shall include:

   a. Major conduit feeder layout.
   b. Floor duct system layout, furniture connections.
   c. Cable tray routing and locations.
   d. Switchboard and panel locations.
   e. Light fixture locations, book-shelves lighting installation and their underground conduit rough-in.
   f. Pull box locations.
   g. Vertical Lift electrical rough-in and connection.
   h. Fire Alarm system layout.
   i. Drawings shall be in AutoCad, Release 14 or latest version, 1/4" = 1'-0" scale, 30" x 42" size floor plans, including sections and elevations.

2. Furnish coordination drawings timely to meet construction schedule. Attend coordination meetings with the mechanical, plumbing, fire protection, structural and architectural trades before installation of work in this Division.

3. See Section 230500 1.07 coordination with Division 25. Design Builder shall attend periodic job site coordination meetings. It is Design Builder's responsibility to coordinate major electrical run, such as conduits, feeders, duct banks, floor duct system, cable trays and etc., with the 3D coordination model development. Otherwise. Design Builder may have to pay for additional expense (money) as directed by Division one for assisting coordination of other trades in the development of the coordination.

B. Coordinate electrical work with other Divisions to:
1. Avoid interference among general construction, mechanical, electrical, structural and other trades.

2. Maintain clearances and advise other trades of clearance requirements for operation, repair, removal and testing of electrical equipment.

3. Indicate aisle-ways and access-ways required on coordinated shop drawings for electrical and telephone rooms, mechanical equipment rooms, computer rooms, laboratories, and kitchens.

4. All electrical materials and equipment shall be kept close to the ceiling, walls and columns to occupy the minimum amount of space and comply with code required access and clearances.

5. Furnish and install all offsets, fittings, and similar items necessary to accomplish the requirements of coordination, as part of the work.

6. Verify electrical rating of Vertical Lift, mechanical and plumbing equipment, and equipment furnished by other Divisions before conduit rough-in and delivery of protective circuit devices. Submit to the Owner written evidence that Design Builder complied with this requirement. If Design Builder did not do checking and proceeded with work and later have to change it because the electrical drawings are different from mechanical and other trades, Design Builder shall be responsible for correcting work at no additional cost to the Owner.

1.16 PERSONNEL DEMONSTRATION AND TRAINING

A. Provide the Owner's personnel with demonstration and training on the systems installed according to the amount of time indicated in individual equipment sections of Division 26. Where no time is specified, the minimum for actual demonstration and training time shall apply:

1. Fire alarm system: 8 hours.

2. Lighting control system: 8 hours.

B. Where two or more of the above systems are combined, the total training time for the combined system shall equal the sum of the training times for the individual systems.

C. Demonstration and training shall be done by qualified representatives of the equipment manufacturer. Notify Owner not less than two weeks in writing that work have been checked, tested and operated, and that the equipment and systems are working as specified, and that Design Builder is ready to schedule demonstration and training.

PART 2 - PRODUCTS

2.01 MATERIAL

A. The design, manufacture and testing of electrical equipment and materials shall conform to or exceed latest applicable UL, NEMA, IEEE and ANSI standards.
B. All materials shall be new and bear UL label. Materials that are not covered by UL testing standards shall be tested and approved by an independent testing laboratory. The laboratory shall be acceptable to the Owner.

C. Furnish materials and equipment that are products of a reputable manufacturer regularly engaged in manufacture of the specified item. Where more than one unit is required of any item, furnish the equipment by the same manufacturer, except where specified otherwise.

D. Owner has the authority to require removal of material or work from the premises if work is not in accordance with the Drawings and Specifications. He may also require replacement of unsatisfactory work or material. Owner has authority to stop work whenever such stoppage may be necessary to insure proper execution of the Contract.

E. Furnish and install equipment necessary for proper operation of the system. Furnish, install, adjust, and leave in a safe and satisfactory condition all materials and equipment mentioned in the Specifications, shown on the Drawings, or both. Furnish and install supplies, appliances, and connections necessary to the proper operation of the equipment, including access doors where required.

F. Access doors shall be provided where required to access wiring and equipment and shall be sized as specified herein and in accordance with Code. Type, finish, location, fire rating, etc., shall be submitted for review. Access doors are not shown on the drawings and Design Builder shall be responsible for locating and providing same as part of the work.

G. Compatibility of electrical systems with building control system: All equipment listed below shall be compatible with Division 23 building control system:

1. Fire alarm system
2. Electrical equipment energy monitoring and control systems
3. Variable frequency drives

2.02 ACCESS DOORS AND PANELS

A. Access doors and panels: Specification of access doors and panels is under Division 8.

2.03 ELECTRICAL IDENTIFICATION MATERIALS

A. General: Provide manufacturer's standard products of categories and types specified and required for each application, except as otherwise indicated.

B. Color-Coded Conduit Markers:

1. General: Provide manufacturer's standard pre-printed, flexible or semi-rigid, permanent, plastic-sheet conduit markers, and extending 360 degrees around conduits; designed for attachment to conduit by adhesive, adhesive lap joint of marker, matching adhesive plastic tape at each end of marker, or pre-tensioned snap-on. Except as otherwise indicated, provide nomenclatures which indicate
the voltage or system of the conductors in conduit, e.g., 120/208 volts, normal or emergency power, fire alarm, etc. Provide 8" minimum length for 2" and smaller conduit, 12" length for larger conduit.

a. Colors: Unless otherwise indicated or required by governing regulation, provide orange markers with black letters. Use red markers for fire alarm conduits. Use yellow markers for telecommunications and signals.

b. Lettering: minimum 1-1/2" high.

C. Color Coded Plastic Tape:

1. General: Provide manufacturer's standard self-adhesive vinyl tape not less than 3 mils thick by 1-1/2" wide.

a. Colors: Unless otherwise indicated or required by governing regulations, provide orange tape.

b. Use red tape for fire alarm conduits. Use yellow tape for telecommunications and signals.

D. Cable and Conductor Identification Bands:

1. General: Provide manufacturer's standard vinyl-cloth self-adhesive cable and conductor markers of the wrap-around type; either pre-numbered plastic coated type, or write-on type with clear plastic self-adhesive cover flap; numbered to show circuit identification.

E. Plasticized Tags:

1. General: Manufacturer's standard pre-printed or partially pre-printed accident-prevention and operational tags, of plasticized card stock with matte finish suitable for writing, approximately 3-1/4" x 5-5/8", with brass grommets and wire fasteners, and with approximate pre-printed wording including large-size primary wording (as examples; DANGER, CAUTION, DO NOT OPERATE).

F. Self-Adhesive Plastic Signs:

1. General: Provide manufacturer's standard, self-adhesive or pressure-sensitive, pre-printed, flexible vinyl signs for operational instructions or warnings of sizes suitable for application areas and adequate for visibility, with proper wording for each application (as examples; 208V, exhaust fan).

a. Colors: Unless otherwise indicated or required by governing regulations, provide orange signs with black lettering.

2. Baked Enamel Danger Signs:

a. General: Provide manufacturer's standard "Danger" signs of baked enamel finish on 20 gauge steel; of standard red, black and white graphics; 14" x 10" size except where 10" x 7" is the largest size which
can be applied where needed, and except where larger size is needed for adequate vision; with recognized standard explanation wording (as examples: HIGH VOLTAGE, KEEP AWAY, BURIED CABLE, DO NOT TOUCH SWITCH).

G. Engraved Plastic Laminate Nameplates:

1. General: Provide engraving stock melamine plastic laminate complying with FS-LP-387, in sizes and thicknesses indicated, engraved with standard letter style of the sizes and wording indicated, black letter style of the sizes and wording indicated, white background except as otherwise indicated, punched for mechanical fastening except where adhesive mounting is necessary because of substrate. Use red background with white lettering for emergency power system and circuits, and fire alarm system.

   a. Thickness: 1/16” for units up to 20 sq. in. or 8” length; 1/8” for larger units.

   b. Fasteners: Self-tapping stainless steel screws, except use contact-type permanent adhesive where screws cannot or should not penetrate the substrate.

H. Circuit Identification Labels for switches, receptacles, exit signs and light fixtures.

1. Circuit identification tape labels shall indicate panel and circuit. Lettering shall be black color and 3/16” high on white background.

2. Apply on the front face of receptacle and switch coverplates.

3. Apply on light fixture junction box covers, exit sign mounting buses, and exterior of remote LED driver enclosures.

I. Pull Tapes

1. Provide pull tape in all empty conduits. Pull tapes shall be labeled with footage markings, WP 25 Arnco Bull Line AD technologies.

J. Lettering and Graphics

1. General: Coordinate names, abbreviations and other designations used in electrical identification work, with corresponding designations shown, specified or scheduled on the drawings. Provide numbers, lettering and wording as indicated or, if not otherwise indicated, as recommended by manufacturers or as required for proper identification, and operation and maintenance of the electrical systems and equipment.

2. Lettering Height and Nomenclature

   a. Lighting and receptacle branch circuit panelboards. Provide engraved nameplates.
1) Nomenclature: Three lines minimum; first line - panel name e.g. PANEL L2A; second line - voltage, number of phases and wires e.g. 120/208V, 3-phase, 4W; third line - source of power, e.g. "fed from distribution panel “XXXX”

2) Letter Height: 1/2 inch high first line, 1/4 inch for second and third lines.

b. Distribution panels and transformers: same as lighting and receptacle panelboards.

c. Disconnect switches and enclosed circuit breakers: same as lighting and receptacle panelboards.

d. Switchboards: Provide engraved nameplates.

1) Nomenclature: Three lines: first line - equipment designation, e.g. "main switchboard (or switchgear) "XYZ”, second line - voltage and number of phases and wires, e.g. 480/277V, 3-phase, 4W; third line - source of power e.g., "Fed from North Vault" (indicate location of service).

2) Letter Height: 1/2 inch high first line, 1/4 inch for second and third lines.

e. Variable Frequency Drives, and Motor Control Center: same as switchboards.

f. Terminal Cabinets and Pull Boxes: Provide engraved nameplates.

1) Nomenclature: Minimum one line and indicate conductors or system contained; example: FIRE ALARM, 120/208 VOLTS, etc.

2) Letter Height: 1/2 inch high.

g. Junction and outlet boxes in ceiling spaces: On the outside face of the cover, identify panel and circuit numbers contained inside of outlet and junction boxes, with a black permanent felt pen marker.

2.04 GROUNDING

A. Electrodes

1. Electrolytic Ground Rods

a. Ground Rods shall be a self-contained system consisting of a 10-foot vertical copper tube with drilled holes, containing non-hazardous Calsolyte® salts. System shall be permanently capped at the top and bottom ends. All Electrical connections to the ground rods shall be made via exothermic welding. All cables shall be copper. Backfill material
shall be natural volcanic non-corrosive form of Bentonite, free of polymer
sealants and bear the NSF mark. Backfill shall have maximum resistivity
of 60 ohm-cm at 30% solids density and be near neutral pH.

b. System shall be UL listed.

c. System shall include a 30-year minimum warranty with 50-year life
expectancy.

d. System access from grade shall incorporate the use of composite
Fibrelite inspection box (text well) model XB12-F load rated for
incidental traffic. Box shall be installed flush with finished grade.

e. Manufacturers: Lyncole XIT Grounding – K2-10CS2/0D or K2L-
10CS2/0D, or equal.

B. Copper Ground Wire

1. Medium hard drawn copper conductor, stranded, sizes as shown on the
drawings.

C. Below Grade Fittings

1. Manufacturers: Lyncole, Burndy, or equal.

2. All direct buried ground connections shall meet IEEE 837 and shall be UL listed.

D. Hardware

1. Bolts, nuts, and washers shall be bronze, cadmium plated steel, or other non-
corrosive material, approved for the purpose.

2.05 FIRE STOPPING

A. Comply with Division 7 requirements. Seal all electrical system components passing
through fire rated walls and floors. Hilti, 3M or equal.

PART 3 - EXECUTION

3.01 COORDINATION

A. Coordinate work with other trades and Divisions of these specifications to avoid conflict
and eliminate delays, keep all trades informed of proposed installations under this
Division, and to provide correct rough-in and connection for equipment furnished under
trades. Inform other trades of the required access and clearances around electrical
equipment to maintain serviceability and code compliance.

B. Verify equipment dimensions and requirements with under this Section. Check actual job
conditions before fabricating work. Make necessary changes in time to prevent needless
work.
C. Prior to rough-in and conduit work, check electrical characteristics of all equipment to be supplied under other Divisions and this Division and compare with circuiting shown on the drawings and actual equipment. Examples of this are elevators, motors, mechanical units, kitchen equipment, doors, etc. Inform the Owner Representative of variance between equipment to be supplied and electrical drawings. Failure on the part of Design Builder to do this checking and resulted in conflict with equipment and installed wiring, the Design Builder shall correct work to suit equipment at no additional cost to the Owner.

3.02 QUALITY ASSURANCE

A. The specifications contained minimum acceptable requirements. Design Builder shall provide a complete operating facility within the scope of this work. The Agreement for Mechanical and Control Design-Build Project applies to this section.

B. Design Builder shall ensure that workmanship, all materials employed, all equipment, and the manner and method of installation conforms to Code and accepted construction and engineering practices, and that each piece of equipment is in satisfactory working condition to perform its functional operation. The Design Builder shall ensure that each individual piece of equipment operates in the overall system and is properly wired, and controlled to enable all electrical systems in the building to function properly together.

C. Grounding Connectors
   1. All connectors must meet the requirements of IEEE Standard 837.

3.03 MEASUREMENTS AND DIMENSIONS

A. Unless otherwise directed, or unless dimensions are shown on electrical drawings, obtain all dimensions from architectural, civil, structural, or mechanical drawings as applicable. Do not scale from electrical drawings, which are intended to be diagrammatic only.

B. Where the sign "+" followed by a dimension is shown on electrical drawings, it means the distance from finished grade or finished floor to the horizontal centerline of the electrical device or equipment.

C. Examine the areas and conditions under where work will be performed. Correct conditions detrimental to timely and proper completion of the work. Do not proceed until unsatisfactory conditions are corrected.

3.04 MANUFACTURER'S RECOMMENDATIONS

A. Where installation procedures or any part thereof are required to be in accordance with manufacturer's recommendations, furnish printed copies of the recommendations prior to installation. Installation of the equipment or item shall not proceed until manufacturer's recommendations are received. Failure to furnish recommendations shall be cause for rejection of the equipment or material.

3.05 FIRE STOPPING

A. Comply with Division 7 requirements. Seal all electrical system components passing through fire rated walls and floors.
3.06 CUTTING AND PATCHING

A. All cutting and patching required for work of this Division shall be included herein. Coordination with other Divisions shall be performed by the Design Builder. Responsibility for and adjustment of improper holes, supports, etc., shall be by the Design Builder.

B. Cut completed construction work only if sleeves, openings, chases, etc. where omitted, and only with specific permission of the Engineer. Reinforcing steel shall not be cut without written permission of the Owner.

C. Provide sleeves, caps, plates, escutcheons, flashing, etc., required to fill or close the openings. Provide final grouting, concrete, asphalt, masonry, painting and other surface materials as required. Make repairs in like and kind for exact matching of surfaces and finishes.

D. Where cutting and patching occurs in streets, sidewalks, alleys and the like, cooperate fully with Owner and municipal or other government bodies.

E. Perform all core drilling only as approved by the Owner Representative. Jack hammering is not permitted. Arrange for all patching required and seal floor penetrations watertight. Before starting drilling operations, locate steel reinforcing bars and electrical conduits embedded in the concrete slabs by X-ray or other approved method to prevent cutting of steel bars and conduits. Maximum size of opening shall be 5" in diameter, unless otherwise noted on drawings or permitted in structural drawings.

F. Seal all penetrations at fire rated construction with approved fire sealing system.

G. Seal all penetrations through the roof and slab on grade with approved sealing system.

3.07 CLEANUP

A. Comply with requirements of the Agreement for Mechanical and Control Design-Build Project and the following:

1. Remove tools, scaffolding, surplus materials, barricades, temporary walks, debris and rubbish from the project promptly upon completion of that portion of the work of each section. Leave the area of operations completely clean and free of these items.

2. During construction; cap all electrical conduits in approved manner to insure protection against entrance of foreign substances.

3. Disconnect, clean and reconnect wherever necessary to locate and remove obstructions from any system stopped by any foreign matter after being placed in operation. Repair or replace any work damaged in removing obstructions at no additional cost to the Owner.
3.08 ACCESS DOORS AND PANELS

A. This Section is responsible for the number of doors required and their accurate placement for access to work of Division 26.

1. This Section is responsible for arranging equipment so that it is fully accessible and serviceable through ceiling tiles, access doors, panels, etc.

2. The Section is responsible for any additional access panels beyond what is shown on the contract documents for complete access to all wiring and equipment including equipment which is relocated as a result of the coordination process or equipment that is provided as performance requirements.

3. This Section shall obtain approval from the Owner's Representative for any added or relocated access doors, panels, etc.

3.09 ELECTRICAL IDENTIFICATION

A. General Installation Requirements:

1. Coordination: Where identification is to be applied to surfaces which require finish, install identification after completion of painting.

2. Regulations: Comply with governing regulations and requests of authorities having jurisdiction for the identification of electrical work.

B. Conduit Identification:

1. General: Where electrical conduit is exposed in spaces with exposed mechanical piping which is identified by a color-coded method, apply color-coded identification on electrical conduit in a manner similar to piping identification.

C. Cable and Conductor Identification:

1. General: Apply cable and conductor identification to each cable and conductor in each box or enclosure or cabinet where wires of more than one circuit or communication or signal system are present. Match identification with marking system used in panelboards, shop drawings, contract documents, and similar identification for electrical work.

D. Operational Identification and Warnings:

1. General: Wherever required to ensure safe and efficient operation and maintenance of the electrical systems, and electrically connected mechanical systems and general systems and equipment, including the prevention of misuse of electrical facilities by unauthorized personnel; install self-adhesive plastic signs or equivalent identification, instruction or warnings on switches, outlets and other controls, devices and covers of electrical enclosures. Where detailed instructions or explanations are needed, provide plasticized tags with clearly written messages adequate for the intended purposes.
E. Danger Signs:

1. General: In addition to installation of danger signs required by governing regulations and authorities having jurisdiction, install danger signs at locations indicated and at locations subsequently identified by installer of electrical work as constituting similar dangers for persons in or about project.

F. Equipment and System Identification Nameplates:

1. General: Install an engraved plastic laminate nameplate on each major unit or electrical equipment in the building, including central or master unit of each electrical system, unless unit is specified with its own self-explanatory identification or signal system. Provide text with matching terminology and numbering of the contract documents and shop drawings. Provide engraved nameplates for each unit of the following categories of electrical work.

   a. Panelboards, electrical cabinets and enclosures.
   b. Access doors to electrical facilities and wiring.
   c. Motor control centers, motor starters, VFDs, contactors and disconnects.
   d. Transformers.
   e. Fire detection, alarm and communications systems panels.
   f. Lighting control panels.
   g. Terminal cabinets and pull boxes.

2. Install signs at locations indicated or where not otherwise indicated, at location for best viewing without interference with operation and maintenance of equipment. Secure to substrate with fasteners, except use adhesive where fasteners should not or cannot penetrate the substrate.

G. Wiring Device Circuit Identification Nameplates

1. General: Provide all switch and duplex receptacle cover plates with panel and circuit identification clear tape labels.

H. Junction and outlet boxes: Mark the covers of junction and outlet boxes of the panel and circuit numbers inside the boxes with black felt pen.

3.10 GROUNDING

A. System Neutral Ground

1. Ground the neutral conductor of each transformer to limit the maximum potential above ground due to normal operating voltage and limit the voltage level due to abnormal conditions.
B. Equipment Ground

1. Ground non-current carrying metal parts of electrical equipment enclosures, frames, conductor raceways 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. 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 250-95, unless otherwise shown on drawings.

2. Grounding conductors shall be identified with green insulation. Where green insulation is not available on larger wire sizes, black insulation shall be used and suitably identified with green tape at each junction box or device enclosure.

3. Install metal raceway couplings, fittings and terminations secure and tight to insure good ground continuity.

4. Feeders and motor branch circuits: Provide grounding bushing and bonding jumper where metal raceway is not directly attached to equipment metal enclosure and at concentric knockouts.

5. Motors shall be connected to equipment ground conductor with a conduit grounding bushing at the motor terminal box and with a bolted solderless lug connection on the metal frame from the conduit grounding bushing.

6. All polarized receptacles, lighting fixtures, and equipment enclosures shall be grounded with an identified (green color) insulated conductor, no smaller than No. 12, connected to the branch circuit panelboard ground bus terminal strips. The ground bus terminal strip in each panelboard enclosure shall be isolated and independent of the system neutral terminal strip, but not isolated from the panelboard enclosure. Ground the outlet boxes, light fixture housing and equipment enclosures to the equipment grounding conductors. Splice the equipment grounding conductor and make the connection to the outlet boxes, light fixtures, receptacles and equipment enclosures.

C. General Grounding

1. All ground connections that are buried or in inaccessible locations shall be welded or silver soldered. The process shall join all strands and shall not in any way cause the parts to be damaged or weakened.

2. The welding process shall be exothermic fusion type which will make a connection that will not corrode or loosen. The completed connection or joint shall be equal or larger in size than the conductors joined and shall have the same current-carrying capacity as the largest conductor. The ground connection shall be painted with a bit-mastic (corrosion retardant) paint.

3. Ground connections in accessible locations shall be bolted, except that any required connections to steel building columns in either accessible or inaccessible locations shall be exothermically fusion-welded.
4. All ground connection surfaces shall be cleaned and all grease and foreign contamination removed. Clad material shall not be penetrated in the cleaning process. Connections shall be made between like metals where possible. Where dissimilar metals are welded, brazed, or clamped, the weld kit manufacturer’s instructions shall be followed.

3.11 TESTS

A. General:

1. In addition to complying with Section 260126, comply with testing requirements as specified herein, governing authorities having jurisdiction and test requirement of other sections of this Division.

2. Obtain approval for test procedures. The Owner and authority having jurisdiction shall be notified a minimum of seventy-two (72) hours in advance of tests, unless otherwise noted. Any test conducted without notification shall be subject to retest at the discretion of the Owner without additional cost to Owner.

3. Tests shall be performed and systems approved, prior to painting, covering, insulating, furring, or concealing piping, as applicable. Prior to test, protect or remove all control devices and other items which are not designed to stand parameters used in test.

4. Provide labor, materials, instruments and power required for testing under respective sections for work under that section.

5. Adjust, repair, or replace defective work and repeat tests until systems and component parts receive approval of Owner and regulating authorities. Damages resulting from tests to electrical systems or to work of other trades shall be repaired and restored to their original condition as directed by Owner at no additional cost to the Owner.

6. Test all systems as specified under various applicable sections. Duration of tests shall be determined by authority having jurisdiction, where applicable, and in no case less than the time specified.

7. Provide all required testing, and repeated testing until the authority having jurisdiction and Owner is satisfied that work is in accordance with Contract Documents.

8. Adjust, repair, or replace at no additional cost to the Owner, any portion of work which fails to meet the specified requirements as noted on the tests.

9. Make all final tests in the presence of the authorities having jurisdiction.

10. Furnish copies of tests reports and certificates of acceptance, signed by the authorities having jurisdiction, to Owner before submitting for final payment; such payments will not be processed until these submittals have been made.
3.12 ACCEPTANCE DEMONSTRATION

A. Upon completion of the work, at a time to be designated by the Owner’s Representative, the Design Builder shall demonstrate the operation of the electrical installation, including any and all special items installed by him or installed under his supervision, to Owner's Representative and Owner's satisfaction.

B. Owner’s Representative may require operation of parts or all of respective installations prior to final acceptance.

C. Operation of installation shall not be construed as acceptance of work.

END OF SECTION
PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Conduits and other raceways.
B. Wires and cables.
C. Outlet boxes, junction boxes and pullboxes.
D. Hangers and supports.
E. Safety disconnect switches.
F. Equipment mounting and support hardware.
G. Wiring devices and coverplates.
H. Vibration isolation.
I. Waterproofing assemblies.
J. Miscellaneous materials not specifically mentioned in other sections of Division 26, but necessary or required for equipment or system operation of function, and the labor to install them.

1.02 REFERENCES

A. NEMA KSI: Enclosed Switches.
B. NEMA WD1: Wiring Devices.
C. NEMA WD5: Specific Purpose Wiring Devices.
D. UL 1: Flexible Metal Conduit.
E. UL 5: Surface Metal Electrical Raceway and Fittings.
F. UL 6: Rigid Steel Conduit, Zinc Coated.
G. UL 44: Rubber-Insulated Wire and Cables.
H. UL 50: Electrical Cabinets and Boxes.
I. UL 83: Thermoplastic-Insulated Wires.
J. UL 486: Wire Connectors and Soldering Lugs.
K. UL 493: Thermoplastic-Insulated Underground Feeder and Branch Circuit Cables.
L. UL 514: Electrical Outlet Boxes and Fittings for Non-Hazardous Location.
M. UL 797: Electrical Metallic Tubing.
N. UL 1242: Intermediate Metal Conduit.

1.03 SUBMITTALS

A. Submit in accordance with the requirements of Agreement for Mechanical and Control Design-Build Project and Section 260500.

B. Materials list for all materials with manufacturer, style, and series or model identified.

C. Manufacturer's descriptive literature and samples if requested by the Owner.

D. Shop Drawings:
   1. Prepare shop drawings for any areas in which installation will differ from the contract documents, including re-routing of raceway and relocation of equipment, coordination with other Divisions, including structural, mechanical, and architectural.
   2. Shop drawings shall show means of bracing all conduits and equipment to comply with seismic requirements of Section 260529.
   3. Shop drawings shall show exact routing of raceways, cable trays, distances between conduits in or beneath slabs, means of suspension and bracing; including any required panel schedule changes; and new locations of equipment to be installed.
   4. All shop drawings shall be submitted to the Owner for approval before installation.
   5. Surface metal raceway locations, dimensions, outlet type and location, and circuiting.
   6. Prior to installation, prepare and submit shop drawings of major and feeder runs of conduits 1-1/2 inch and larger size, exposed and concealed locations, and under the building floor slab on grade locations.

E. Submittals for Vibration Isolation:
   1. The submittal for electrical equipment vibration isolation shall include information for the isolation mounts, as follows:
a. A complete description of products to be supplied, including product data, dimensions, specifications, and installation instructions.

b. Detailed selection data for each vibration isolator, supporting equipment, including:
   1) The equipment identification mark;
   2) The isolator type; and
   3) The actual load.

2. Submission of samples may be requested for each type of vibration isolation device. After approval, samples will be returned for installation at the job. All costs associated with samples shall be borne by the Design Builder.

PART 2 - PRODUCTS

2.01 GENERAL

A. Capacity and Performance

1. Provide necessary calculations for correct sizing of equipment and materials for the specific application.

2.02 CONDUITS AND OTHER RACEWAYS

A. Manufacturers: National Electric Products Corp., Republic Steel Corp., United States Steel, Western Tube and Conduit Corp, or equal.

B. Rigid steel conduit shall conform to U.L. 6. Zinc coating shall be applied inside and out by hot-dip galvanizing after threading. Minimum size shall be 1/2” unless specifically noted, conduit homeruns shall be 3/4” minimum size. Heavy wall or intermediate wall conduit installed per Code or as specified.

C. Rigid Steel Conduit Fittings: Locknuts shall be extra heavy electro-galvanized steel for sizes through 2”. Locknuts larger than 2” shall be electro-galvanized malleable iron. Bushings shall be electro-galvanized malleable iron with insulating collar. Grounding bushings shall be locking type and shall be provided with feed through compression lug. Liquid-tight hubs with insulated throats shall be provided for all connections to sheet steel enclosures. Rigid conduit shall be used with threaded fittings only.

D. Electrical Metallic Tubing (EMT): Shall be electro-galvanized and comply with U.L. 797. Minimum size shall be ¾” inside diameter, except conduit used to connect to one light fixture shall be 1/2” minimum size.

E. Flexible Metal Conduit: Shall be formed spirally wound galvanized steel strip with successive convolutions securely interlocked, conforming to U.L. Maximum allowed length shall be six feet. Minimum size shall be 1/2” inside diameter.
F. Liquid-tight Flexible Metal Conduit: Shall be formed from spirally wound galvanized steel strip with successive convolutions securely interlocked, jacketed with liquid-tight plastic cover. Minimum size shall be 1/2" inside diameter; maximum allowed length shall be six feet, unless otherwise noted.

G. Intermediate Metal Conduit (IMC) shall be listed by U.L. and shall bear their listing mark.

H. Fittings for outdoor work shall be of cast, shall have threaded hubs, and insulated throats.

I. Fittings for rigid metallic conduit and electrical metallic tubing shall conform to U.L. standard 514 for nonhazardous areas only. Rigid conduit shall be used with threaded fittings only. Split couplings are not acceptable. All box connectors shall be provided with nylon insulation for EMT, and bonding and grounding type for rigid conduits. Connectors shall have nylon insulated throats.

J. Fittings for electrical metallic tubing (EMT) for sizes 1/2" through 4" shall be compression type which shall provide pull-on force resistance and electrical continuity as required by U.L. 514. Indenting fittings shall not be used. Connectors shall have nylon insulated throats.

K. Fittings for flexible metal conduit shall conform to U.L. standard 514 and shall be cadmium or zinc-coated. Connectors shall have nylon insulated throats.

L. Cast metal conduit bodies shall conform to U.L. Standard 514 and shall be cadmium or zinc-coated if of ferrous metal. Outlets shall be gasketed and provided with cap over each opening. The cap shall be permanently attached to the coverplate by a short length of bead chain or shall be provided with a spring-hinged flap. Conduit bodies with PVC coating shall have a minimum 40 mil thickness of PVC coating.

M. Junction boxes and covers shall conform to U.L. Standard 514 for non-hazardous areas.

N. Non-Metallic conduit shall be Schedule 40, high impact polyvinyl chloride. Fittings used with PVC conduit shall be PVC solvent weld type. Manufacturers: Carlon, Triangle, Johns-Manville, or equal.


P. Conduit sleeves (for non-waterproof locations):

1. Steel sleeve schedule 40 for above slabs on grade.

2.03 WIRES AND CABLES

A. All conductors shall be copper, conforming or exceeding applicable ICEA standards.

B. For power distribution systems 600V or less, insulation type:

1. Stranded copper conductor.

2. Wire Size #12 AWG through #8 AWG:
a. Type TW or THHN in dry location.

b. Type THW or THHN in wet locations.

3. Wire Size #6 AWG and larger: Type XHHW in dry or wet locations.

4. Wire within conduits in damp locations or in concrete in contact with the ground: RHW insulation.

5. Where required by equipment nameplate, use high temperature rated conductors.

6. Grounding wire: THWN.

7. Ampacity rating for wires: Per NEC Table 310-16 at 75°C temperature column or column of lug temperature rating whichever is lower.

C. Conductors for general branch circuits: Copper conductor, #12 AWG minimum, except as otherwise noted on the drawings.

D. Wire and cable for communication, data, security and fire alarm systems shall be as specified under the separate headings for these systems.

E. All cables used in cable tray shall be U.L. listed for use in cable trays, in accordance with CEC Article 318-3.

F. Where required by code, cables shall be approved for plenum installation, when installed within ceiling space used as air handling space.

G. Manufacturers: Anaconda, Okonite, Cyprus-Rome, Triangle, or equal.

2.04 WIRE JOINTS, CONNECTIONS AND SUPPORTS

A. Joints of conductors rated up to 600 volts shall be made mechanically and electrically secured by using one of the following methods:

1. Connections to Circuit Breakers and Switches:

   a. No. 12 wire: Formed around binding post or screw.

   b. No. 10 and No. 8 wire: Locking tongue lug. Manufacturers: Buchanan Termend, Thomas and Betts, or equal.

   c. No. 6 wire and larger: Round flange solderless lug. Manufacturers: Burndy Quiklug Type QDA, Penn Union, or equal.

2. Connections to Fixtures: Make circuit wiring connections to fixture wire with insulated electrical spring connectors. Threaded-type wire nuts, porcelain or bakelite are not acceptable.
3. Wire Joints:
   a. No. 6 and larger. Manufacturers: Burndy Type QPR, Penn Union, or equal.
   b. No. 8 and smaller: Pigtail splices as described below, or made with insulated electrical spring connectors. Manufacturers: 3M Scotchlok Insulated Electrical Spring Connectors, Thomas and Betts, and 3M Scotchcast 82 Series Resin Splicing Kits, Thomas and Betts, or equal.
      1) Where underground and high moisture area connections are required to be insulated, use approved moisture-proof epoxy resin splicing kits.
      2) Insulate uninsulated solderless connections for wires, the same as pigtail splices.

B. Supports for Vertical Wiring: OZ Gedney type R, Appleton, or equal cable support plugs.

2.05 OUTLET BOXES, JUNCTION AND PULL BOXES

A. Outlet boxes: Hot-dipped galvanized, 4” square by 2-1/8”deep, minimum, for flush mounted devices and lighting fixtures. Cast type with gasketed covers for outdoor or wet locations. Extra-large and extra deep sizes as required by device or equipment and code, or indicated on drawings.

B. Junction and Pull Boxes: Use outlet boxes as junction boxes wherever possible. Larger junction and pull boxes located indoors shall be fabricated from galvanized sheet steel, NEMA-1, with screw-on covers, and gray baked enamel finish. Where located outdoors or in wet locations, shall be NEMA 3R.

2.06 CONDUITS SUPPORT SYSTEM

A. Comply with the requirements of Section 260529.

B. For individual conduit run on the surface of the building structure:
   1. Use 1-hole conduit clamps for conduit 1-1/2” and smaller.
   2. Use 2 hole style for conduits 2” and larger. Manufacturers: Appleton, O.Z. Gedney, Unistrut, or equal.

C. For multiple conduit runs (two or more conduits) on the surface of the building:
   1. Fasten to U-channel strut system Unistrut P1000, B-Line Strut, or equal with
Conduit clamps. Fasten channel strut system Unistrut P1000, B-Line Strut, or equal to the building.

D. For individual conduit run not on the surface of the building, it shall be pendant mounted and installed as follows:

1. Conduit size 1-1/2" and smaller: Use 1/4" diameter threaded hanger rod with O-Z Gedney Cat, or equal. No. H-XXBS series conduit hangers Unistrut, B-Line, at 8'-0" on centers. Grainger, or MSC, or equal.

2. Conduit size 2" and larger: Use 1/4" diameter threaded hanger rods with Unistrut Cat. No. J12XX Series conduit hangers, Unistrut, B-Line, at 8'-0" on centers. Grainger, or MSC, or equal.

3. Seismically braced per the requirements of Section 260529.

E. For multiple conduit runs not on the surface of the building, it shall be pendant mounted and provided with trapeze type conduit support system. Supports to be installed at maximum spacing of 8'-0". Trapeze support shall consist of U-channel strut system, hanger rods, conduit clamps and fittings and fastening devices. Multiple conduit runs are runs of two or more conduits, regardless of trade sizes. Hanger rods shall be threaded and 1/4" diameter minimum size. Comply with CBC requirements and the requirements of Section 260529.

F. Provide necessary clamps and fastening hardware for fastening conduit trapezes per the requirements of Section 260500 and the CBC.

G. Rod hangers, trapeze and bracing hardware shall be as manufactured by Unistrut, Superstrut, Powerstrut, or equal. Utilize approved suspension and seismic bracing system of the manufacturer selected. Comply with CBC requirements and the requirements of Section 260529.

H. All rods, clamps, etc., suspended from concrete decks, concrete slabs on metal decks, etc., shall be supported by Hilti Kwik Bolt III, Phillips red-head drilled in wedge type or expansion anchors, or equal, and shall be installed in accordance with Division 3 and manufacturer's instructions. All other supports shall be from structural members, utilizing beam clamps that shall be compatible with structural members.

I. Within metal studs of gypsum or plaster walls:

1. Caddy No. 781, Raco, or equal.

2. Black iron wires.

2.07 SAFETY DISCONNECT SWITCHES

A. Heavy duty type, 240V or 600V, HP rated for motors, standard NEMA 1 enclosure indoor dry locations, and NEMA 3R outdoor locations, fused or non-fused as required. Switches shall be three pole single throw unless otherwise indicated on drawings to be four pole double throw (4P DT). Suitable for service entrance where indicated on drawings. Manufacturers: Cutler-Hammer, Square D, Siemens, General Electric, or equal.
Switch Interior: Dead-front construction with hinged arc suppresser and switch blades which are visible in the "OFF" position and with door open.

Switch Mechanism: Quick-make and quick-break operating handle and mechanism with a dual cover interlock to prevent unauthorized opening of the switch door in the "ON" position or closing the switch mechanism while the door is open. "ON" position shall be in the upward direction for vertical mounted switches.

Fuses for 600 amperes or less: Current limiting, dual element, U.L. Class RK5.

Provide disconnect switch at mechanical motor fan controller if integral disconnect switch is not provided with the controller. Coordinate with mechanical trades.

2.08 EQUIPMENT MOUNTING AND SUPPORT HARDWARE

A. Steel channels, bolts, washers, etc., used for mounting or support of electrical equipment shall be galvanized type, except where located on roof, shall be stainless steel.

2.09 WIRING DEVICES

A. All wiring devices shall conform to U.L. 20 and NEMA WDI for current and voltage indicated, heavy duty specification grade. Manufacturers: Hubbell, Arrow Hart, Pass and Seymour, or equal. Numbers listed are those of Hubbell, unless otherwise noted:

B. Switches:

1. Switches mounted indoors shall be rated at 20 amps, 120-277 volts AC and shall have binding screws for side wiring. Switches shall be Hubbell catalog numbers 1221-WHI for single pole, 1222-WHI for double pole, 1223-WHI for three-way, and 1224-WHI for four-way.

2. Switches mounted outdoors or within six (6) feet of sinks shall have weatherproof neoprene gray color covers equal to Arrow Hart Cat. No. 2881, OR Hubbell, Pass and Seymour.

3. Color shall be white, unless otherwise noted. Verify color with the Owner prior to submission of submittals.

C. Receptacles (Hubbell numbers indicated):

1. 20 amperes, 125 volts, 2-pole, 3-wire grounding, duplex receptacle, 20 amperes, 125 volts, 2-pole, 3-wire grounding, duplex receptacle, No. 5362-WHI. (NEMA 5-20R).

2. 20A, 2-pole, 3-wire, GFI, 125V, duplex ground fault receptacle, No. GF5362-WHI. (NEMA 5-20R).

3. Receptacles shall be white, unless otherwise indicated. Verify color with Architect prior to submission of submittals.

4. Other receptacles designated by NEMA number on drawings shall be as
manufactured by Hubbell, Arrow Hart, Pass and Seymour, or equal.

D. Isolated ground type: 20A, 125V, 2-pole, 3-wire, isolated ground, orange color. #IG5362

E. Controlled duplex receptacle: 20A, 125V, 2-pole, 3-wire grounding, engraved to indicate "controlled". #BR20C2-WHI

F. Half-controlled duplex receptacle: 20A, 125V, 2-pole, 3-wire grounding, engraved to indicate "controlled" on one receptacle. #BR20C1-WHI

G. Motor Rated Switches: Fractional horsepower motors with integral overload protection shall be equipped with appropriately sized AC manual motor starting switches without overload protection. Switches with overload protection shall be provided for all other fractional horsepower motors. Manufacturers: Cutler Hammer, Square D, Siemens, General Electric, or equal.

H. Floor Boxes: Legrand 6AT series poke through for power and data furniture feeds.

2.10 COVERPLATES

A. Interior:

Plates: Hubbell, Leviton, Arrow-Hart, Bryant, Pass & Seymour or equal.

<table>
<thead>
<tr>
<th>Type</th>
<th>Catalog No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single gang wall switch</td>
<td>P1</td>
</tr>
<tr>
<td>Single gang duplex receptacle</td>
<td>P8</td>
</tr>
<tr>
<td>Single gang single receptacle</td>
<td>P7</td>
</tr>
<tr>
<td>Duplex receptacle, ground fault interrupter</td>
<td>HPSII</td>
</tr>
<tr>
<td>Single gang wall switch, weather-proof, Pass &amp; Seymour</td>
<td>WP1</td>
</tr>
</tbody>
</table>

Plates for all other special devices in these locations shall be smooth nylon or thermoplastic matching the foregoing. Provide matching ganged plates for devices mounted side by side.

B. Coverplates for manual starters to have "ON-TRIP-OFF" engraved adjacent to handle.

C. Exterior of Building: Cast metal, vertical mounting for duplex receptacles and switches, hinged type, weatherproof while in-use with 1/8" thick gasketing, lockable. Intermatic WP series, Hubbel, or equal.

D. Provide blank coverplates for all unused outlet boxes, including but not limited to:

1. Lighting and power.
2. Spare or empty outlet boxes.

2.11 VIBRATION ISOLATION

A. General: Furnish and install vibration control devices, materials, and related items. Perform all work as specified herein to provide complete vibration isolation systems in proper working order. Comply with the requirements of Section 230548 – Vibration
Controls for HVAC Piping and Equipment.

B. Material and Equipment

1. All vibration isolation mounts shall be supplied by one of the manufacturers listed herein.

C. Quality Assurance:

1. Coordinate the size, location, and special requirements of vibration isolation equipment and systems with other trades. Coordinate plan dimensions with size of housekeeping pads.

2. Provide vibration isolators of the appropriate sizes and proper loading to meet the specified requirements.

3. Supply and install any incidental materials needed to meet the requirements stated herein, even if not expressly specified or shown on the drawings, without claim for additional payment.

4. Verify correctness of equipment model numbers and conformance of each component with manufacturer's specifications.

5. Should any electrical equipment cause excessive noise or vibration, the Design Builder shall be responsible for remedial work required to reduce noise and vibration levels. Excessive is defined as exceeding the manufacturer's specifications for the unit in question.

6. Upon completion of the work, the Owner shall inspect the installation and shall inform the Design Builder of any further work that must be completed. Make all adjustments as directed by the Owner that result from the final inspection. This work shall be done before vibration isolation systems are accepted.

D. Products

1. Vibration Isolation Mount Types

   a. Unit DNP (Double Neoprene Pad)

      1) Neoprene pad isolators shall be formed by two layers of 1/4" to 5/16" thick ribbed or waffled neoprene, separated by a stainless steel or aluminum plate. These layers shall be permanently adhered together. Neoprene shall be 40 to 50 durometer. The pads shall be sized so that they will be loaded within the manufacturer's recommended range. A steel top plate equal to the size of the pad shall be provided to transfer the weight of the supported unit to the pads and to distribute the load evenly over the surface of the pads.

      2) Manufacturers: Unit DNP isolators shall be formed from one of the following products:
1) Type NR Amber/Booth, Mason Industries, or equal.

2) Type Korpad Korfund Dynamics, Mason Industries, or equal.

3) Type WSW Mason Industries, Korfund Dynamics, or equal.

4) Type NPS Peabody Noise Control, Mason Industries, or equal.

5) Series Shear Flex Vibration Mountings & Control, Mason Industries, or equal.

2. Flexible Electrical Connections
   a. Provide liquid-tight flexible conduit connections to vibrating equipment or machines such as motors, transformers, etc. Provide minimum 50% more conduit slacks.

PART 3 - EXECUTION

3.01 GENERAL

A. Electrical system layouts indicated on the drawings are generally diagrammatic, but shall be followed as closely as actual construction and work of other trades will permit. Govern exact routing of raceway, cable trays, wiring, locations of equipment, and outlets by the structure and the equipment served. Take all dimensions from Architectural drawings. Coordinate work with architectural, civil, landscape, structural, and mechanical drawings.

B. Avoid cutting and boring holes through structure or structural members. Obtain prior approval of the State and conform to all structural requirements when cutting or boring the structure is necessary and permitted.

C. Furnish and install all necessary hardware, hangers, blocking, brackets, bracing, runners, etc., required for equipment specified under this Section.

D. Provide necessary backing required to ensure rigid mounting of outlet boxes.

E. Provide sound proofed seals for all conduit penetration through sound rated walls and floor. Provide sound proofed seals for all junction boxes located at sound rated walls. See Architectural drawings for location of all sound rated wall and floor. See drawings for requirements.

3.02 WIRING METHOD

A. Install all wiring in raceway.

B. Sizes for conduits, unless specifically shown, shall be determined from Table 3A, Chapter
9 of the latest National Electric Code for all 600V rated conductors, based on type THW insulation.

C. Minimum conduit size shall be 3/4” inside diameter and 1” C for underground installation.

D. Raceway and box sizes for telephone, signal, television and data systems shall be as indicated in Drawings.

E. All raceways shall be rigid conduit unless otherwise indicated or permitted by this Section. All raceway material delivered to the jobsite shall bear the U.L. label and shall be stored so as to be protected from physical damage and weather elements.

F. EMT may be used when concealed in walls or ceiling, within electrical, telephone, and mechanical rooms, and in exposed indoor locations not subject to damage.

G. Plastic conduit may be used underground except as otherwise noted, run beneath warning slab or slab on grade.

H. Conduits, fittings, conduit bodies, and outlet boxes.

I. Use flexible conduits in the following applications:
   1. At transformers and other vibrating equipment.
   2. Connections between light fixtures and junction box at lay-in grid ceilings.

J. Use liquid tight flexible conduits with threaded waterproof fitting in the following applications:
   1. Exterior locations.
   2. Wet locations.
   3. Motors (in dry or wet locations).
   4. Building expansion joints.

K. Use rigid steel conduit in concrete slabs and walls; minimum size 1”. All conduit installed in concrete must have structural engineer’s approval of size, number, and location prior to installation.

3.03 INSTALLATION OF CONDUITS

A. Conceal conduits in walls, ceilings, and slabs where possible; otherwise run exposed parallel or at right angles to center lines of columns and beams. Exposed conduits are permitted only within the electrical and telephone rooms, and mechanical rooms. Provide required coring and notching to pass through joists, walls and floors.

B. Conduits in mechanical, electrical and telephone rooms may be installed exposed. In all electrical rooms mechanical rooms, and telecom rooms, no conduits shall be installed horizontally on walls, which may block future equipment space.
C. Conduits not cast in concrete shall be supported by galvanized wall brackets, ceiling trapeze, malleable straps or "mineralac" clamps. Conduit shall be supported at intervals of not more than ten (10) feet. Conduit installed within metal studs shall be provided and secured to brackets and secured to metal studs with fasteners or black iron wires that go around conduits twice and are twisted with a minimum of 4 turns.

D. Provide conduit sleeves and chases wherever conduits pass through floors and concrete foundations. Set in forms before concrete is poured. All penetrations of roofs and exterior walls shall be flashed and counter-flashed to preserve waterproof integrity of the building. Comply with details on architectural drawing for conduit roof penetrations. Material and techniques used shall conform to roof or wall waterproofing specifications. All exterior wall and slab penetrations shall be made watertight. Use PVC schedule 40 for underground installation. All 12KV services conduits shall be concrete encased.

E. Flexible conduits and expansion fittings shall be installed at all expansion joints in the building. Use flexible conduits for indoors and expansion fittings for outdoors. Refer to structural and architectural drawings for extent and criteria of building movement. If none shown, use two times the seismic joint dimension plus 50% of joint dimension for the length of fittings or flexible conduits movement.

F. Conduits, wireway or cable tray passing through fire rated walls and floors shall be firestopped and fireproofed to maintain the integrity of the fire rated wall or floor. Conduits shall not penetrate fire rated shafts and stair walls.

G. Seal all conduits passing through mechanical plenums, noise control walls, and similar locations. Seal the gaps around conduits.

H. Waterproofing Assemblies: Conduits penetrating exterior foundation below grade shall be provided with waterproofing assemblies. Seals shall be cast in wall with sleeve, with pressure ring inside of structure.

I. All underground conduits and ducts 2" and larger shall be proven clear by pulling through a mandrel 1/4" smaller than the conduit inside diameter.

J. PVC conduits shall not be installed in slabs or concrete walls above finished grade or inside the building and outdoors exposed.

K. Steel wire hangers, suspended from structure or fastened to the structural columns or beams are not acceptable installation methods for suspended or pendant conduits.

L. Provide empty conduits with nylon insulated throats and pull strings.

M. Underground conduits from the site entering the building shall be routed and installed in accordance with the requirements of structural drawings and specifications.

N. Conduits shall not penetrate fire rated shafts and stair walls unless that conduits serve the shafts and stair walls.

O. Cap all spare conduits.

P. Conduits shall not run on roof decks. Run conduits at roof areas surface mounted to
structural steel members and equipment pads.

Q. Seal all underground conduits at pull boxes after conductors are installed.

3.04 INSTALLATION OF WIRES

A. Pull no wire into any portion of the conduit system until all construction work which might damage the wire has been completed.

B. Install all wires continuous from outlet to outlet or terminal to terminal. Splices in cables when required shall be made in approved fittings; handholes, pull boxes or junction boxes. Make branch circuit splices in outlet boxes with 10 inches of correctly color-coded tails left in the box.

C. Splices in wires and cables shall be made utilizing materials and methods as specified herein.

D. Install 1/8" diameter pull line in all empty conduits except where noted and specified otherwise. Manufacturers: Tubbs Cordage Company yellow "polyline", Jet Line, or equal.

E. Provide wire markers on all conductors in each junction or pull box, and at each terminal point. Marker shall include panel and circuit number for each wire, and line designation number for equipment wiring. Manufacturers: Brady, Panduit, or equal.

F. Provide legible permanent markings on covers of all junction boxes and pull boxes within ceiling spaces to indicate panel and circuit numbers within box.

G. Branch Circuit Homeruns: When branch circuit homeruns exceed the length indicated below, the Design Builder shall install minimum wire sizes as follows:

1. For homeruns exceeding 100 feet up to 180 feet maximum of 20 ampere capacity circuits, use minimum #10 AWG wires.

2. For homeruns exceeding 180 feet up to 250 feet maximum of 20 ampere capacity circuits, use minimum #8 AWG wires.

3. For homeruns exceeding 250 feet of 20 ampere capacity circuits, size wire as required to avoid exceeding 3% voltage drop from the panel to farthest outlet or load.

4. Unless otherwise specified, size conduit homeruns accordingly as permitted by NEC Table 9.

5. The preceding wire sizes noted shall start from the panel to the first outlet.

6. This requirement shall govern over what is shown on the plans.

H. Branch Circuit Wiring:

1. Quantity of wires for receptacle and lighting branch circuit wiring shall be in
accordance with circuiting and switching or control arrangement, and as herein specified.

a. 4 wires plus ground: For three 20A, (or 15A), 1-pole, 120 volt (or 277 volt) circuits.

b. 3 wires plus ground: for two 20A, (or 15A), 1-pole, 120 volt (or 277 volt) circuits.

c. 2 wires plus ground: for one 20A, (or 15A), 1-pole, 120 volt (or 277 volt) circuit.

d. Per Single Pole Switch: Minimum 2 wires plus ground wire.

e. Two Light Switches from Same Circuit: Minimum 3 wires plus ground wire.

f. Per 3-way Light Switch: Minimum 3 wires plus ground wire.

g. Two 3-way Light Switches for Same Circuit: Minimum 5 wires plus ground wire.

h. Green insulated ground wire shall be provided for all circuits.

2. Homeruns and branch circuiting unless otherwise shown on the plans, electrical drawings, and lighting plans.

I. Supports for Vertical Wiring: Provide in vertical conduit runs at a maximum spacing of 30 feet for the support of the conductors.

3.05 WIRE COLOR CODE

A. Color code and wire tag all conductors. Wires shall have integral color code insulation.

B. Color code insulation of wires as follows:

<table>
<thead>
<tr>
<th>Conductors</th>
<th>120/208 Volts</th>
<th>277/480 Volts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase A</td>
<td>Black</td>
<td>Brown</td>
</tr>
<tr>
<td>Phase B</td>
<td>Red</td>
<td>Orange</td>
</tr>
<tr>
<td>Phase C</td>
<td>Blue</td>
<td>Yellow</td>
</tr>
<tr>
<td>Neutral</td>
<td>White</td>
<td>White or gray</td>
</tr>
<tr>
<td>Ground</td>
<td>Green</td>
<td>Green</td>
</tr>
</tbody>
</table>

C. Color coding of wires used for signal and communication systems are specified under the respective sections for these systems.

D. Motor Circuits:

1. Motor Power Conductors: In accordance with color coding specified in Part 3.5B.

2. Motor Control Conductors
   For 1/C Wires
Wire 1 - Red
Wire 2 - White
Wire 3 - Yellow
Wire 4 - Blue
Wire 5 - Orange
Wire 6 - Brown
Wire 7 - Purple

3. For Multiconductor or Composite Cables: All control wires shall be of a neutral color (white and green colors are unacceptable) with printed numbers starting with number 1. Tag wires at all ends.

3.06 CONNECTIONS TO EQUIPMENT

A. Furnish and install required power supply conduit and wiring to all equipment.

B. Install all rough-in work for equipment from approved shop drawings to suit the specific requirements of the equipment.

C. Mechanical, Plumbing, Architectural, and Other Design Builder-Furnished and Owner-Furnished Equipment:

1. All required power conduit, wiring and connections are included under this Section of the work. Control, sensing and alarm devices will be furnished under the respective section of the specification supplying the equipment unless noted otherwise. Where these are located in pipes, ducts, vessels, tanks, etc., they shall be mounted in place by the Design Builder furnishing the devices. All others shall be mounted under this Section of the work.

D. Control panels for packaged equipment shall be furnished under the respective Section of the specification supplying the equipment unless otherwise noted. Installation and connection of the control panels are under this Section of the work.

E. Starters for motors associated with mechanical (non-packaged) equipment not specified under other sections of the specifications shall be furnished and installed under this section.

3.07 MOUNTING HEIGHTS

A. Refer to architectural drawings and electrical legend sheet for mounting heights of devices and equipment.

3.08 DEVICES, WALL SWITCHES, RECEPTACLES, AND DISCONNECT SWITCHES

A. The location of all outlets, devices, wall switches, receptacles, and disconnect switches shown on the drawings is approximate, except for those specifically dimensioned. The exact location and height of outlets not shown on Architectural Drawings shall be coordinated with applicable furniture plans, and if required will be determined by the Owner Representative at the time of installation. Cooperate with other trades to avoid conflict between the location of outlets, ventilating ducts, plumbing pipes and fixtures, furniture installations, etc. Outlet boxes mounted outside the building or at exterior
locations shall be waterproof cast type.

B. All boxes shall be independently secured and shall not rely on the conduit system to hold them in place.

C. All outlet boxes installed in plastered walls shall be equipped with plaster rings, except where otherwise specified.

D. Pull boxes and junction boxes mounted outdoors shall be weatherproof and galvanized. Pull boxes and junction boxes mounted indoors may be galvanized or primed and painted.

E. Outlet boxes, pull boxes and junction boxes cast in concrete shall be galvanized.

F. Outlet boxes used to support lighting fixtures shall be securely attached to supports suitable for carrying the weight of the fixtures, and shall have fixture studs. Lighting fixtures shall not be supported by box covers.

G. Outlet boxes mounted on opposite sides of the same wall shall have not less than 12” horizontal separation on non-rated walls and not less than 24” horizontal separation on fire rated walls. If 24” separation cannot be maintained, provide UL listed fire resistant 2-hour rated moldable putty pads over the back and sides of outlet or junction boxes to maintain fire ratings of wall. Manufacturers: Putty pads shall be 3M, Nelson, or equal.

H. Pull-boxes shall be provided when conduit installations have four 90 degree angle bends or the equivalent. Pull-boxes shall be of size in accordance with Code to accommodate splices whether splicing is made or not.

I. Install receptacles with grounding pole at the top.

J. Use jumbo size plates for outlets installed in masonry walls.

K. Where several outlets occur in a room, they shall be located symmetrically.

L. Provide "green" ground pigtail wires, for lighting fixtures and receptacle outlet boxes, bonded to the fixture housing or receptacle outlet box and connected to the ground wire that is installed with branch circuit wires, and grounded to the receptacle ground connection.

M. Outlet boxes for switches and receptacles shall be installed flush mounted in walls with extension device rings. Mount outlet boxes on brackets if required to be centered between partition studs.

N. Outlet boxes for ceiling and floor mounted wiring devices and connections shall be flush mounted.

O. When mounted vertically, the "ON" position of the disconnect switches and enclosed circuit breakers shall be in the upward direction and "OFF" in the downward direction.

P. Mount disconnect switches adjacent to equipment being served on 12 gage strut channels fasten to the floor or roof areas, or on walls within 10 feet and within sight of the
Q. Outlets, devices, switches, receptacles, disconnect switches and pull boxes located on the roof shall be in NEMA 3R enclosures and supported on 12 gauge galvanized strut channels fastened to the roof. Provide materials and waterproofing at all roof penetrations and at point of attachment between roof surface and supporting members such as strut channels in accordance with details on architectural drawings and as specified herein. Hot dip galvanize all steel parts after fabrication where used outdoors.

R. Clean boxes of debris and remove marks on switch and receptacle cover plates due to packaging protective covers.

S. Caulk and seal gaps behind cover plates.

3.09 TESTING OF WIRING SYSTEMS

A. All wiring and connections shall be tested in accordance with the requirements of Section 260126.

END OF SECTION
PART 1 - GENERAL

1.01 SECTION INCLUDES

A. All carpentry, masonry and steel fabrication involved in making stands and supports for equipment installed under this Division, unless specified otherwise.

B. Furnishing and setting of sleeves, rods, inserts, and support and bracing devices for all conduits and equipment installed under this Division.

C. Sizes and locations of all housekeeping pads, piers, and curbs for work of this Division, unless shown or specified otherwise. See architectural and structural drawings for details.

D. Concrete inertia bases where shown or specified for equipment under this Division.

E. Work Described Elsewhere. Specific applications and features or methods unique to a given phase of work may be delineated in other sections.

1.02 SUBMITTALS

A. Submit in accordance with Agreement for Mechanical and Control Design-Build Project and Section 260500.

1. Structural calculations shall be prepared and stamped by a professional structural engineer licensed in the State of California and shall include, but not be limited to the following:

a. A repetition of the design criteria contained in the specifications. Conform to requirements of the CBC, unless otherwise noted in the specifications.

b. Calculations to determine dead, live, and earthquake loads of components and component supports.

c. Analysis of component anchorage and supports to the main structure.

d. Cross reference structural calculations to the applicable production and erection shop drawing details.

e. Show the loads applied to the main building structure in shop drawings or in drawings in the calculations with clear references to locations in the main building structure.

2. Connections to structure.
3. Steel for supports.
4. All fabricated steel and concrete bases.
5. Pre-engineered seismic bracing systems.
6. Shop Drawings
   a. Dimensioned plans showing dimensioned sizes and locations of curbs, pads, and inserts.
   b. All fabricated equipment supports and inertia bases.
   c. Support and bracing details, including bracing, for conduits, busduct, cable tray, wireways, and suspended equipment.

1.03 OPERATIONS AND MAINTENANCE
A. Submit under provisions of Agreement for Mechanical and Control Design-Build Project and Section 260500.
   1. Support devices.
   2. Anchor devices.
   3. Seismic bracing devices, systems, and calculations

1.04 REGULATIONS
A. Seismic Restraint: California Building Code
B. Expansion Anchors: California Building Code

PART 2 - PRODUCTS
2.01 ATTACHMENTS TO STRUCTURE
A. Connection to Concrete Structure: Hilti Kwik-Bolt 3, ITW Redhead, or equal, wedge type expansion anchors.
   1. Provide 30 stainless steel expansion bolts in Mechanical Level and inside air plenums.
   2. Powder driven fasteners are not allowed.
B. For Suspension from New Formed Concrete Structure: B-Line B3014, Grinnell Figure 282, Superstrut 452, or equal, adjustable concrete insert.
C. For suspension from New Concrete on Metal Deck: B-Line B3019, Superstrut C-475, or equal.
D. For Support on New Concrete: Galvanized steel hook bolts.

E. Welded Connection to Steel Beams: B-Line B3083, Grinnell, Superstrut, or equal, steel welded beam attachment.

F. Clamp Connection to Steel Beams: B-Line, Grinnell, Superstrut, or equal, beam clamp with retaining clip style as required by load.

2.02 SUPPORTS, BRACING, AND ACCESSORIES

A. Miscellaneous Steel: Angles, channels, brackets, rods, clamps, etc., of new materials conforming to ASTM A36.

1. Hot-dip galvanize all steel parts after fabrication where used outdoors or inside in the mechanical level.

2. 304 stainless steel for underground pipe support from ground floor structure.

B. Fasteners: All bolts and nuts, except as otherwise specified, shall conform to ASTM Standard Specifications for Low Carbon Steel Externally and Internally Threaded Standard Fasteners, Designation A307. Bolts shall have heavy hexagon heads, and nuts shall be of the hexagon heavy series. Provide bolts of ample size and strength for the purpose intended.

1. All bolts, washers, nuts, anchor bolts, screws and other hardware used above the fifth floor (outdoors or covered), shall be galvanized, and all galvanized nuts shall have a free running fit.

2. All ferrous metal components below grade shall be 304 stainless steel.

C. Sheet Metal Screws: Plated, size 10 minimum.

D. Hanger Rods: B-Line, Grinnell, Superstrut, or equal, plated steel rods, threaded, with a minimum safety factor of 5 over the imposed load.

1. Hot-dip galvanized above roof (outdoors or covered), and electro-galvanized indoors.

E. Conduit Hangers: See Section 260502 – Basic Materials and Methods. Provide rod sizes to meet Section 260502 requirements and the requirements of this section.

2.03 SEISMIC RESTRAINT

A. Materials: Steel and fasteners as specified herein.

B. Electrical Conduits, wire-ways, Cable Tray, Boxes, and Equipment Restraint:

1. Design nonstructural component and equipment anchorage to the main structure including component parts, connections and related hardware, per California Building Code Section 1632a, so that the completed installation meets or exceeds the following requirements:
a. Importance Factor for Seismic Loading (I_P):

1) $I_P = 1.5$ for Life Safety Systems

2) Switchgear, switchboards, distribution panels, transfer switches, distribution panels, transformers, panelboards, motor control centers, conduit, etc. connected to or being served by the emergency branch of the electrical system.

3) Exit lights.

4) Emergency lights.

5) Switchgear, switchboards, distribution panels, panelboards, motor control centers, conduit, etc. systems.

6) $I_P = 1.0$ for all other systems

b. Seismic Zone: 4

c. Ca Value for use in CBC Section 1632: 0.36.

d. Horizontal Force Factor values, $a_P$ and $C_P$, are from CBC Table 16-O.

e. Building heights are as shown in the Drawings.

f. Service Seismic Drift, $D_s$: 0.005 times building height.

g. Maximum Seismic Drift, $D_M$: 0.015 times building height.

h. Utilize custom engineering and/or pre-engineered seismic restraint systems. In either case, provide structural calculations stamped by a Professional Structural Engineer licensed in the State of California including, but not limited to the following:

1) A repetition of the design criteria contained in the specifications. Conform to requirements of the CBC, unless otherwise noted in the specifications.

2) Calculations to determine dead, live, and earthquake loads of components and component supports.

3) Analysis of component anchorage and supports to the main structure.

4) Cross reference structural calculations to the applicable production and erection shop drawing details.
PART 3 - EXECUTION

3.01 ATTACHMENTS TO STRUCTURE

A. Concrete Structure:

1. Locate anchors at least six (6) bolt diameters from any edge condition and at least ten (10) bolt diameters from any other anchor. Provide a minimum of six (6) bolt diameters embedment into concrete, unless otherwise noted on the Drawings.

2. Limit load at concrete-filled steel deck to no more than 750 pounds per flute per beam bay (approximately 7 feet). Weights exceeding this restriction to be supported from the steel structural elements using engineered spreaders attached to the structural steel.

3. See Structural Drawings for additional restrictions for locating anchors.

4. Conform to CBC for drilled-in expansion bolts.

B. Steel Structure: Attach at beam axis. Avoid eccentric loads wherever possible.

1. Where slack cable bracing is used, the cable size, spacing, and connection are to be as recommended by the slack cable bracing system manufacturer.

C. Rating: Ultimate strength at least five times the imposed load.

D. Coordinate installation so that attachments to structure are made prior to fireproofing. If attachments must be made after fireproofing, then thoroughly clean area of fireproofing before welded or bolted attachments are made and replace fireproofing as necessary.

E. Where point loads, imposed by work of Division 26, are greater than can safely be carried by the deck, provide structural steel spreader beams tied to the building structure. Submit details of all such spreader beams for approval.

3.02 SUPPORTS, BRACING, AND ACCESSORIES

A. This Section is responsible for the proper selection and sizing of all support, bracing, and guiding elements of any single or trapeze systems that include duct, pipe, and/or electrical conduit, wire-way, or cable trays, including those in the laboratories. The Design Builder shall retain the services of a specialty support system provided to evaluate all loads due to weight, seismic forces, thermal expansion, etc., and perform all calculations and prepare detailed shop drawings for complete support, bracing, guiding, and anchoring systems based on the layouts shown on the Drawings.

5) Show the loads applied to the building structure in shop drawings or in drawings in the calculations with clear references to locations.
1. All support, bracing, guiding, and anchoring systems used outside and in the mechanical level or outdoors to be galvanized.

B. Set all machines and devices dead level, except where pitch or slope is specified or shown, and securely fasten to the structure unless shown otherwise. Use dry pack cement grout to obtain complete contact between structure and equipment. Provide steel bracing as shown and specified to resist earthquake loads.

C. Concrete Work: Pads, curbs, and piers for equipment furnished under this Division shall be located and sized under this Division and installed by Design Builder. Inform Division 3 that all concrete shall be finished and surface hardened. This Section is responsible that forms, anchors, embeds, embedded channels and bases are properly set in the correct location. Carefully lay out all anchor locations before concrete is poured.

1. Provide housekeeping pads for all equipment provided unless specifically indicated otherwise. Nominal size is 4 inches high unless indicated otherwise.

D. Conduit, Rack, and Cable Tray Support and Bracing:

1. Support Devices: per the requirements of this section and Sections.

2. Provide bracing longitudinally and transversely in accordance with specified guidelines. See Seismic Restraint hereinbefore.

3. Brace conduit trapeze where the cumulative weight of conduits exceeds the weight of a single 2-inch pipe.

4. Install sleeves wherever pipes are run through walls, and floors to allow large enough openings for the passage of the pipe and pipe insulation when required. Sleeves shall be of sufficient size to allow for contraction and expansion of pipe. The space between each pipe and sleeve (or insulation and sleeves) shall be completely closed by packing with code approved mineral fiber materials with a suitable binder or other approved packing material. Sleeves at floors are to extend 2" minimum above structural slab or finished floor whichever applies. Seal all penetrations through all fire rated construction (walls, ceilings, floors) with approved materials providing equivalent protection and rating of the construction being penetrated.

5. Support all conduits and cable tray from the building structure so that there is no apparent deflection in the runs. Do not support from, or brace to, ducts, other pipes, conduit, or any materials except building structure. Any exposed or concealed conduits which can be physically moved, and which is not properly supported will not be accepted, and additional support or bracing will be required. Install seismic bracing as hereinbefore specified; see Seismic Restraint.

6. Install and secure all equipment with anchors and braces to floors, structural members and walls with sufficient backing, to prevent vibration and/or horizontal displacement under load and seismic force as hereinbefore specified. Follow manufacturer's recommendations for the installation of vibration isolators where required for all equipment requiring such.
7. Provide field built conduit anchors for building expansion joint and thermal expansion control.

E. Support and brace all equipment, devices, conduits, etc. located at upper roof either from the equipment pads or from the overhead framing structure. Do not support or brace from the roof. When supporting from or bracing to overhead, provide all intermediate steel required between structural steel members.

F. Equipment Resiliently Mounted

1. All electrical equipment which is mounted on spring mounts or resilient pads shall be restrained to prevent lateral, vertical, and overturning movement. Restraining devices shall be installed on all sides of equipment. Devices shall be sized in accordance with the requirements of this Section and as shown on the approved shop Drawings.

G. Equipment Suspended from the Structure Above

1. Suspended equipment shall be restrained to prevent lateral and vertical movement. Restraint devices shall be sized in accordance with the requirements of this Section and as shown on the approved shop Drawings.

2. Included is all suspended electrical equipment such as pull-boxes.

3.03 ADJUSTING AND TESTING

A. Prior to installing conduit bracing, alternate expansion type anchors shall be tested to four times the allowable load. Anchors immediately adjacent to the failed anchors shall also be tested. Obtain Owner's Representative approval prior to replacing failed anchors.

END OF SECTION
PART 1 - GENERAL

1.01 SECTION INCLUDES
   A. Panelboards

1.02 REFERENCES
   A. The panelboards and all components shall be designed, manufactured and tested in accordance with the latest applicable standards of NEMA and UL as follows:
      1. UL 67 -- Panelboards
      2. UL 50 -- Cabinets and boxes
      3. NEMA PB1
      5. Circuit breaker -- Type I class I
      6. NRTL National Recognized Testing Lab.

1.03 SUBMITTALS
   A. The following information shall be submitted to the Owner Representative:
      1. Breaker layout drawing with dimensions indicated and nameplate designation
      2. Component list
      3. Conduit entry/exit locations
      4. Assembly ratings including:
         a. Short-circuit rating
         b. Voltage
         c. Continuous current
      5. Cable terminal sizes.
   B. Submit 10 copies of the above information.
C. When requested by the Owner Representative the following product information shall be submitted:

1. Descriptive bulletins
2. Product sheets.

D. The following information shall be submitted for record purposes:

1. Final (as-built) drawings and information for items listed in section 1.4.
2. Installation information.
3. Seismic certification and equipment anchorage details.
4. Documentation of power monitoring/metering IP addresses.

1.04 QUALIFICATIONS

A. The manufacturer of the panelboard shall be the manufacturer of the major components within the assembly, including circuit breakers and fusible switches.

B. For the equipment specified herein, the manufacturer shall be ISO 9000, 9001 or 9002 certified.

C. The manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of five (5) years. When requested by the Owner Representative, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.

D. The panelboards shall be suitable for and certified to meet all applicable seismic requirements of California Building Code (CBC) for zone 4 application.

E. Comply with the requirements of electrical seismic restraint systems in Section 260529.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Equipment shall be handled and stored in accordance with manufacturer's instructions. One (1) copy of these instructions shall be included with the equipment at time of shipment.

B. Equipment shall be shipped in its original packages, to prevent damaging or entrance of foreign matter. All handling and shipping shall be performed in accordance with manufacturer's recommendations.

C. Provide protective covering during construction.

D. Replace at no expense to Owner, equipment or materials damaged during storage or handling, as directed by the Owner.
E. All items shall be tagged with a weatherproof tag identifying equipment by name and purchase order number. Packing and shipping lists shall be included.

1.06 OPERATION AND MAINTENANCE MANUALS

A. 10 copies of the equipment Operation and Maintenance manuals shall be provided.

B. Operation and maintenance manuals shall include the following information:
   1. Instruction books and/or leaflets.
   2. Recommended renewal parts list.
   3. Drawings and information required by section 1.04.

PART 2 - PRODUCTS

2.01 GENERAL

A. Capacity and Performance: See drawings for nominal selections.
   1. Provide necessary calculations for correct sizing of equipment for the specific application.

2.02 MANUFACTURERS

A. Manufacturers: Eaton Electrical, Siemens or equal. Model numbers indicated are those of Eaton Electrical.

2.03 RATINGS

A. Panelboards rated 240 Vac or less shall have short-circuit ratings greater than the available fault current, but not less than 10,000-amperes RMS symmetrical. See drawings for other requirements.

B. Panelboards rated 480 Vac shall have short-circuit ratings greater than the available fault current, but not less than 14,000-amperes RMS symmetrical. See drawings for other requirements.

C. Panelboards shall be labeled with a UL short-circuit rating. When series ratings are applied with integral or remote upstream devices, a label or manual shall be provided. It shall state the conditions of the UL series ratings including:
   1. Size and type of upstream device
   2. Branch devices that can be used
   3. UL series short-circuit rating.
2.04 CONSTRUCTION

A. Shall be suitable for service entrance application where indicated on drawings.

B. Interiors shall be completely factory assembled devices. They shall be designed such that switching and protective devices can be replaced without disturbing adjacent units and without removing the main bus connectors.

C. Trims for lighting and appliance panelboards shall be supplied with a hinged door over all circuit breaker handles. Doors in panelboard trims shall not uncover any live parts. Doors shall have a semi-flush cylinder lock and catch assembly. Doors over 48 inches in height shall have auxiliary fasteners. Doors shall be door-in-door construction.

D. Distribution panelboard trims shall cover all live parts. Switching device handles shall be accessible. Panels shall be 36” wide and 11” deep minimum.

E. Surface trims shall be same height and width as box. Flush trims shall overlap the box by 3/4 of an inch on all sides.

F. A typewritten circuit directory card with a clear plastic cover shall be supplied and mounted on the inside of each door and shall be 8-1/2” x 11” size. Indicate area and rooms and equipment or type of loads served, feeder size, source of service (e.g., fed from distribution panel 3ARA), amperes and voltage, loads of all branch circuits.

G. Locks shall be stainless steel. All locks shall be keyed alike.

H. Multi-section panelboard:

1. When more than 42 over-current protective devices are required, two or more separate enclosures shall be required. Separate fronts for each box shall be provided.

2. Interconnecting multi-section panelboards: When a panelboard, for connection to one feeder, must be furnished in more than one section (box), each section must be furnished with main bus and terminals of the same rating, unless a main over-current device is provided in each section.

3. Through-feed lugs: The incoming feeder cables shall be connected to the main lugs or main breaker at the bottom of panel Section 1. Another set of lugs (through-feed) are located at the opposite end of the main bus. The interconnecting cables are connected to the through-feed lugs in Section 1 and are carried over to the main lugs in Section 2. The connection arrangement could be reversed, i.e., main lugs at top; through-feed lugs at bottom end or panel. Cross cables shall be provided as part of the work.

2.05 BUS

A. Main bus bars shall be plated copper sized in accordance with UL standards to limit temperature rise on any current carrying part to a maximum of 65 degrees C above an ambient of 40 degrees C maximum.
B. An isolated copper ground bus shall be included in all panels.

2.06 WIRING/TERMINATIONS

A. Circuit Numbering: odd numbers on the left side and even numbers on the right side. Start numbers from top down.

2.07 DISTRIBUTION PANELBOARDS -- CIRCUIT BREAKER TYPE

A. Distribution panelboards with bolt-on devices contained therein shall have fully rated interrupting ratings as indicated on the drawings.

B. Molded case circuit breakers shall provide circuit over-current protection with inverse time and instantaneous tripping characteristics and shall be type Series C or General Electric or Square D or approved equal. Ground fault protection shall be provided where indicated.

C. Circuit breakers shall be operated by a toggle-type handle and shall have a quick-make, quick-break over-center switching mechanism that is mechanically trip-free. Automatic tripping of the breaker shall be clearly indicated by the handle position. Contacts shall be non-welding silver alloy and arc extinction shall be accomplished by means of DE-ION arc chutes. A push-to-trip button on the front of the circuit breaker shall provide a local manual means to exercise the trip mechanism.

D. Circuit breakers shall have a minimum symmetrical interrupting capacity greater than the available fault current. All breakers shall be fully rated; series rater breakers are not acceptable.

E. Where indicated, circuit breakers shall be current limiting.

F. Circuit breakers 400-ampere through 1200-ampere frame shall be type Series C, with microprocessor-based RMS sensing trip units.

1. Each molded case circuit breaker microprocessor-based tripping system shall consist of three current sensors, a trip unit, and a flux-transfer shunt trip. The trip unit shall use microprocessor-based technology to provide the adjustable time-current protection functions. True RMS sensing circuit protection shall be achieved by analyzing the secondary current signals received from the circuit breaker current sensors and initiating trip signals to the circuit breaker trip actuators when predetermined trip levels and time delay settings are reached.

2. Interchangeable rating plugs shall establish the continuous trip ratings of each circuit breaker. Rating plugs shall be fixed or adjustable as indicated. Rating plugs shall be interlocked so they are not interchangeable between frames, and interlocked such that a breaker cannot be closed and latched with the rating plug removed.

3. The microprocessor-based trip unit shall have thermal memory capabilities to prevent the breaker from being reset following an overload condition until after a preset time delay.
4. When the adjustable instantaneous setting is omitted, the trip unit shall be provided with an instantaneous override. Internal ground fault protection adjustable pick-up ratings shall not exceed 1200-amperes. Provide neutral ground fault current sensor for four wire loads.

5. Breakers shall have built-in test points for testing the long-time delay, instantaneous, and ground fault functions of the breaker, by means of a 120-volt operated test set. Provide one test set capable of testing all breakers 400-ampere frame and above.

6. System coordination shall be provided by the following microprocessor-based time-current curve shaping adjustments:
   
   a. Adjustable long-time pick-up
   b. Adjustable short-time pick-up and delay, with selective curve shaping
   c. Adjustable instantaneous pick-up
   d. Adjustable ground fault pick-up and delay, with selective curve shaping.

7. Circuit Breakers shall be Eaton Series C circuit breakers, microprocessor-based RMS sensing trip units type Digitrip RMS 310, SQ D, GE or approved equal.

G. Microprocessor based multi-point metering system

1. Where shown on the drawings, supply a UL listed microprocessor-based Multi-Point Metering System (MPM), Eaton type PX Multipoint Meter or equal having the specified features. This system shall consist of current sensors, meter base, and meter module(s) as described below.

2. The MPM shall have the capability to monitor 60 single-phase two-wire ac loads, 30 single-phase three-wire ac loads or 20 three-phase four-wire ac loads or any combination thereof by use of current sensors.

3. All connections to the MPM shall be through removable plugs.

4. The device shall be capable of accepting input from current sensors by connecting with factory installed plug connectors.

5. The device shall automatically sense the rating of the current sensor.

6. The device shall provide a mechanism for detecting tampering with the current sensors. Tamper detection shall be accessible remotely by computer.

7. The MPM shall be available to accept service type rating from 120-600 Vac voltage rating.

8. The device shall calculate power and energy consumption in accordance with ANSI C12.20 (0.5%) metering specification and stored in non-volatile memory.
9. The device shall store the following per phase and system total for each metering point.
   a. Voltage, Current, and Frequency (system total only)
   b. Real Power in Watts, Reactive power in Var, Apparent energy in VA, and power factor
   c. Real Energy in Watt hours including forward and reverse, Reactive energy in Var hours in Q1-Q4, Apparent energy in VA hours in Q1/Q4, Q2/Q3

10. The MPM shall store energy profile information for each metering point in non-volatile memory. The demand profile time period shall be adjustable from 1, 5, 15, 30 and 60 minutes for fixed method and 1, 5, and 15 minutes for sliding method. The MPM shall have the ability to sync with external input to the onboard demand input. The MPM shall be able to save a minimum of 1 year of load profile data for all 60 meter points on a 15 minutes basis.

11. The device shall be suitable for mounting within a panelboard or switchboard. The device may also be mounted in a separate enclosure.

12. The MPM shall have the capability to scale the number of metering points from 6 to 60 in increments of 6.

13. The MPM shall be UL and cUL listed.

14. The MPM shall have LEDs that can be easily viewed when the unit is installed to aid in the installation and operation of the device with the following functionality:
   a. Each meter base shall have: an LED to indicate power is applied to the unit; an LED to indicate the proper functioning of the system; an LED to indicate the proper functioning of the system; three LEDs, one per phase, to indicate the voltage is within the range of the set nominal voltage; LEDs to indicate Delta and Wye operation; and LEDs to indicate transmit and receive status on RS 485 link.
   b. Each meter module shall have: two programmable LEDs that shall flash in proportion to the amount of energy flowing in the measures circuit with each LED can be assigned to one, two, or three phases; six LEDs that indicate the direction of energy flow per phase; an LED to indicate the proper functioning of the module; and an LED to indicate the proper functioning of communication between the meter base and the meter module.
   c. Each pulse input module shall have: eight LEDs, one per input, to indicate the pulse input status; an LED to indicate the proper functioning of the module; an LED to indicate the proper functioning of communication between the meter base and the input module; and eight LEDs, one per output, to indicate the pulse output status.
d. Each pulse output module shall have: an LED to indicate the proper functioning of the module; and an LED to indicate the proper functioning of communication between the meter base and the output module.

15. The MPM shall have rotary address switches that are easily accessible that set the unit address on the communication network.

16. The MPM shall have two Modbus RTU ports. The communication speed at the device level shall be a minimum of 9,600 baud and maximum 57,600 baud. Devices shall communicate at their maximum baud rate regardless of the number of devices on the network.

17. Meter modules shall be available with support for two three-pole circuits, three two-pole circuits, or six single-pole circuits.

18. Meter modules shall be available to accept 10 mA, 100 mA or 333 mV input signals.

19. Current sensors shall be provided with a toroidal winding over solid core. The winding shall be mounted over the circuit to be monitored by inserting the load conductor through a hole in the center of the current transformers. The current in the load conductor shall be made available to an electronic monitoring device through a four-conductor cable and terminated to a removable plug on the current sensor. The current sensor shall have two LEDs, one red for indicating loss of connection and one blue for verification to connected load. The current sensors shall be suitable for use with circuits rated 125 A through 400 A. Extension cables, with a length of 8 and 16 feet and factory installed connectors shall be available for installations where the standard cable is too short for proper installation. The current sensors shall have 600 V rated cable insulation and shall be UL listed with the MPM.

20. The MPM shall be provided with multiple communications ports and protocols, including the following capability:
   a. RS-485 remote display port
   b. RS-485 Modbus RTU
   c. USB Local Configuration Port
   d. HTML web pages
   e. File transfer protocol (ftp)
   f. RJ-45 10/100Base-T Ethernet network port
   g. BACnet/IP

21. The WEB server shall provide the user with remote WEB access to all the metered and trend information with the optional Energy Portal Module. The WEB
server shall include real time monitored information in both numeric and graphical visual formats.

a. Administrators shall have the following capabilities: add, remove and configure the user accounts; view all the energy, demand, power, voltage, current and power factor measurements available in the meter; and ability to map the meters to the accounts and users.

b. User accounts shall have the following capabilities: view the energy and demand measurements specific to their account; and display the event logs, system logs and load profile data.

22. The meter shall have a real-time clock with the added capability to synchronize with a network time server to maintain time accuracy.

23. The MPM shall have a configuration utility installed on a disc or downloadable from the manufacturer’s website to install on a PC.

a. The configuration utility shall be able to provide online and offline configuration.

b. The configuration utility shall have a wizard to guide the user in step by step setup.

c. The configuration utility shall be able to load a previously saved configuration, save a configuration, and print a configuration.

d. The configuration utility shall be able to configure the service type, set PT and CT ratios, set demand type and intervals along with reset capability on a specific day, configure inputs and outputs, set time, add admin and users with different authorization levels, assign meters to tenants, set alarms and limits, and set network parameters for optional energy portal module.

24. The meter display shall be capable of providing the following Main Meter Menu Screens:

a. System Meter Screen providing:

1) Current per phase and average phase for A, B, and C

2) Volts: L-L and L-N

3) Power, Power Factor and Frequency

4) Power per phase

5) Demand

6) Peak Demand and Timestamp
7)  Energy

b.  Sub Meter Screen providing:
   1)  Configuration
   2)  Power, Power Factor and Frequency
   3)  Demand
   4)  Peak Demand and Timestamp
   5)  Energy

c.  Events Screen providing:
   1)  Latest 20 events with date and timestamps

d.  System Information Screen providing:
   1)  Name
   2)  Part Number
   3)  Serial Number and Date Code

e.  Module Information Screen providing:
   1)  Name
   2)  Part Number
   3)  Serial Number and Date Code

f.  Set-up screen providing:
   1)  View set-up
   2)  Edit set-up
   3)  Login
   4)  Logout

H.  Ethernet Switch:

   1. A single web access point: 4 or 6 port Ethernet switch shall be provided in the
      equipment to allow a single access point for the user and the ability to connect
      more than one network device directly on the customer’s Ethernet Local Area
      Network (LAN).
2. Ethernet switch shall support standard copper RJ45 connectors and/or 100BaseFX Fiber-Optic via ST connectors.

3. Wiring between web enabled devices and Ethernet switches shall be Cat 5e data cable.

I. Provide shunt trips, ground fault protection, and auxiliary switches as shown on the contract drawings.

J. Provide circuit breaker handle lock devices capable of locking all circuit breakers in the "OFF" or "OPEN" position. Provide four locking devices for each type locking mechanism required.

K. Circuit breakers shall be HACR rated when serving heating and air-conditioning equipment.

2.08 BRANCH CIRCUIT PANELBOARDS

A. The minimum integrated short-circuit rating for branch circuit panelboards shall be greater than the available fault current.

B. Bolt-in type, heavy-duty, quick-make, quick-break, single- and multi-pole circuit breakers of the types specified herein, shall be provided for each circuit with toggle handles that indicate when unit has tripped.

C. Circuit breakers shall be thermal magnetic type with common type handle for all multiple pole circuit breakers. Circuit breakers shall be minimum 100-ampere frame and through 100-ampere trip sizes shall take up the same pole spacing. Circuit breakers shall be UL listed as type SWD for lighting circuits.

1. Circuit breaker handle locks shall be provided for all circuits that supply exit signs, emergency lights, energy control system (ECS) panels, and fire alarm panels.

D. Circuit breakers shall have a minimum interrupting rating of 10,000-amperes symmetrical at 240-volts, and 14,000-amperes symmetrical at 480-volts.

E. Provide circuit breaker handle lock devices capable of locking all circuit breakers in the "OFF" or "OPEN" position. Provide four locking devices for each type locking mechanism required.

F. Circuit breakers shall be HACR rated when serving heating and air conditioning equipment.

2.09 ENCLOSURE

A. Enclosures shall be at least 20 inches wide made from galvanized steel. Provide minimum gutter space in accordance with the National Electric Code. Where feeder cables supplying the mains of a panel are carried through its box to supply other electrical equipment, the box shall be sized to include the additional required wiring space. At least four interior mounting studs with adjustable nuts shall be provided.
B. Enclosures shall be provided with blank ends.
C. NEMA 3R enclosures for outdoor locations, and where installed on mechanical level.
D. Stainless steel covers where shown on the drawings.

2.10 NAMEPLATES
A. Provide an engraved nameplate for each panel section, and Arc Flash Hazard Label.

2.11 FINISH
A. Surfaces of the trim assembly shall be properly cleaned, primed, and a finish coat of gray ANSI 61 paint applied.
B. Recess mounted panelboards: Covers shall be painted to match adjacent wall color. Coordinate with architect

PART 3 - EXECUTION

3.01 FACTORY TESTING
A. Standard factory tests shall be performed on the equipment provided under this section. All tests shall be in accordance with the latest version of NEMA and UL standards.

3.02 INSTALLATION
A. The Design Builder shall install all equipment per the manufacturer's recommendations and as specified herein.
B. Set panels plumb and symmetrical with building lines. Furnish and install all construction channel bolts, angles, etc., required to mount the equipment furnished under this section.
C. Free-standing distribution panels shall be accurately aligned, leveled and bolted in place on full-length channels securely fastened to 4" high steel reinforced concrete housekeeping pads.
D. Panelboards shall be anchored and braced to walls or suitable structural framework, in accordance with requirements of Section 260500.
E. Provide mounting brackets, bus bar drillings, and filler pieces for unused spaces.
F. "Train" interior wiring; bundle and clamp, using approved plastic wire wraps.
G. Wall mounted panelboards shall be mounted 6'-6" above finished floor to top of panelboard in electrical rooms and 7'-2" in laboratory corridors.
H. Touch-up paint any marks, blemishes, or other finish damage suffered during installation.
I. Replace panel doors or trim exhibiting dents, bends, warps or poor fit which may impede ready access, security of integrity.

J. Provide "lock-on" devices to circuit breakers serving fire alarm, security, paging, and telecommunications services.

K. Recessed mount panelboards: Provide five 3/4-inch and one 1-inch spare conduits from each panelboard up to the ceiling space, unless otherwise noted on the drawings. Terminate conduits six inches above ceiling space.

L. Comply with the seismic restraint and anchoring requirements of Section 260529.

3.03 FIELD TESTING

A. Refer to Section 260126 for testing requirements.

3.04 CIRCUIT DIRECTORIES

A. Provide an 8-1/2 x 11 circuit directories, similar to the subpanel schedules of the contract documents, that indicate:

1. Panel name,
2. Amperes and voltage,
3. AIC rating,
4. Feeder size (wires and conduits),
5. Loads of branch circuits,
6. Total connected loads,
7. Loads per phase, and
8. Date.

END OF SECTION
SECTION 26 29 13
LOW-VOLTAGE MOTOR CONTROLLERS

PART 1 - GENERAL

1.01 SECTION INCLUDES
A. Low-voltage motor controllers.

1.02 REFERENCES
A. The motor controllers shall be designed, manufactured, and tested in accordance with the latest applicable standards of NEMA, ANSI, NRTL, and UL.

1.03 SUBMITTALS
A. The following information shall be submitted to the Owner Representative:
   1. Master drawing index
   2. Dimensioned outline drawings
   3. Conduit entry/exit locations
   4. Cable terminal sizes
   5. Wiring diagrams
   6. Nameplate schedule
   7. Ratings including:
      a. Voltage
      b. Horsepower and/or continuous current.

B. Submit 10 copies of the above information.

C. When requested by the Owner Representative the following product information shall be submitted:
   1. Descriptive bulletins

D. The following information shall be submitted for record purposes:
   1. Final as-built drawings and information for items listed in section 1.4
1.04 QUALIFICATIONS

A. The manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of five (5) years. When requested by the Owner Representative, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.

B. The motor controller shall be suitable for and certified to meet all applicable seismic requirements of Uniform Building Code (UBC) for zone 4 application. Guidelines for the installation consistent with these requirements shall be provided by the motor controller manufacturer and be based upon testing of representative equipment. The test response spectrum shall be based upon a 5% minimum damping factor, UBC: a peak of 0.75g, and a ZPA of 0.38g. The tests shall fully envelope this response spectrum for all equipment natural frequencies up to at least 35 Hz.

1.05 DELIVERY, STORAGE AND HANDLING

A. Equipment shall be handled and stored in accordance with manufacturer's instructions. One (1) copy of these instructions shall be included with the equipment at time of shipment.

B. Equipment shall be shipped in its original packages, to prevent damaging or entrance of foreign matter. All handling and shipping shall be performed in accordance with manufacturer's recommendations.

C. Provide protective covering during construction.

D. Replace at no expense to Owner, equipment or materials damaged during storage or handling, as directed by the Owner.

E. All items shall be tagged with a weatherproof tag identifying equipment by name and purchase order number. Packing and shipping lists shall be included.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Eaton Electrical, Siemens, or equal.

2.02 MANUAL MOTOR CONTROL

A. Single-Phase Manual Starters

1. Manual single-phase starters 1 hp or smaller shall be Cutler-Hammer type MS starters or SQ D, GE or approved equal. The starter shall have a quick-make/quick-break toggle mechanism. The overload shall have a field adjustment allowing up to +/- 10% variance in ratings of the nominal heater value.
2. Manual single-phase starters above 1 hp shall be Cutler-Hammer type B100 or SQ D, GE or approved equal. The starter shall have quick-make/quick-break mechanism. The closure of the contacts shall be blocked while the line terminals are exposed. The operating handle or button shall clearly indicate whether the unit is ON, OFF or TRIPPED.

3. The enclosure shall be general purpose NEMA 1 for indoor and watertight NEMA 3 for outdoors.

4. The manual motor control shall be Cutler-Hammer type MS or B100 or General Electrical or Square D, or approved equal.

B. Three-Phase Manual Starters

1. The starter shall have quick-make/quick-break operating mechanism.

2. The operating handle or button shall clearly indicate whether the unit is ON, OFF or TRIPPED.

3. The closure of the contacts shall be blocked while the line terminals are exposed.

4. The enclosure shall be general purpose NEMA 1 for indoor and watertight NEMA 3 for outdoors.

5. Manual three-phase motor starters shall be Cutler-Hammer type B100 or General Electrical or Square D or equal.

2.03 MICROPROCESSOR-BASED MOTOR CONTROL (EATON ELECTRICAL ADVANTAGE SERIES)

A. Motor Starters

1. Provide motor starters of the electro-mechanical type with the coil controlled by an application specific microprocessor.

2. Provide one (1) current sensor accurate to 2% for each phase to provide motor running overload protection that yields a time current curve closely paralleling that of the respective motor heating damage boundary. Running overload protection shall be DIP switch selectable for the specific motor full load amperes.

3. Provide DIP switch selectable overload trip class of 10, 20 and 30.

4. Provide phase loss protection and phase unbalance protection. If the phase unbalance on any of two phases is greater than 30% of the DIP switch selected trip rating, a phase loss/unbalance trip occurs.

5. Provide ground fault protection set at 20% of maximum continuous ampere rating with a start delay of 17 seconds, and a run delay of 0.4 seconds to prevent nuisance tripping on startup.
6. Provide each motor starter with a snap-in window which allows clear visibility of overload DIP switch settings and prevents unwanted tampering of DIP switch settings once installed.

7. Provide an application specific microprocessor with the following features:
   a. Microprocessor shall measure control circuit voltage and prevent closing of the coil on voltages below 78 volts AC and/or voltages above 135 volts AC.
   b. Microprocessor shall apply voltage to the coil such that a guaranteed maximum of two (2) milliseconds of main contact bounce occurs on contactor closure.
   c. Microprocessor shall continuously measure coil circuit voltage and current so as to maintain constant coil power at a level to maintain main contact closure and minimize coil power consumption.
   d. Provide electronic circuitry that isolates the coil and is isolated from surges.
   e. Microprocessor shall wait for three (3) half-cycles of control start signal prior to activating a close to prevent starts resulting from momentary voltage spikes, switching transients, fluttering contacts, and shorted programmable logic control outputs. The phase angle of the power in the control circuit is to be compared with the phase angle of the input start signal to prevent starts resulting from capacitively coupled or inductively coupled signals.

8. Motor starters shall have replaceable fixed and movable contacts.

9. All combination starter shall be equipped with integral disconnect switch.

10. Accessories
   a. Motor starter shall be designed to accommodate two (2) auxiliary contact blocks, each capable of a combination of up to four (4) normally closed or four (4) normally open auxiliary contacts. Contacts to be color-coded; black designating NC and silver designating NO. Contacts to be rated ten (10) amperes continuous, 7200 VA make, 720 VA break for 120 through 600 volts AC, and 69 VA make and break for 125 through 300 volts DC. Provide a minimum of one (1) spare NO contact and one (1) spare NC contact in addition to any auxiliary contacts required.
   b. Provide a mechanical interlock on reversing or multi-speed contactors of the lever-type mechanism (with electrical contacts included) to prevent closing of one contactor when the other is closed.
   c. Provide control modules to perform the indicated input/output control functions as shown on the contract drawings. Module to incorporate faceplates having membrane-type pushbuttons and LEDs. All pushbutton
Contra Costa Community College District
Mechanical and Controls Design-Build Project

C-1129 PAC Boiler Replacement  D-1044 Campus-Wide EMS Upgrades
C-1130 PAC Chiller Replacement  D-4017 Mechanical Equipment Retrofit
C-1131 AT Packaged Unit Replacement  P-4022 AHU Replacement

and LED functions shall be furnished with clearly written identification. Control modules shall be provided with 6-foot connection cord and single plug-in wiring to accommodate jack provided in the contactor. Provide as required, modules available to cover applications ranging from full-voltage non-reversing, reversing, multi-speed, and reduced voltage. Modules to be provided with the ability to replace conventional "start", "stop", "hand", and "auto", control functions, and when utilized in starter applications. Modules to be provided with the ability to replace conventional indicating light status of "run", "off", "overload alarm", and "overload trip" when utilized in starter applications.

PART 3 - EXECUTION

3.01 SIZING OF MOTOR STARTER OVERLOAD ELEMENTS

A. Size overload elements specifically for each motor as determined by the service factor and full load current data contained on its nameplate. Where a motor installation includes a power factor capacitor connected to the load side of the motor running overcurrent device, the rating or setting of the motor overcurrent device shall be determined according to such application.

B. Before ordering or accepting any overload elements from the manufacturer, the Design Builder shall prepare a typewritten, identified list on letterhead stationery containing a description of each motor installed to be actually on this project along with its service factor and full load current as obtained from its specific nameplate. This list shall be forwarded to the motor control equipment manufacturer who shall add the catalog number and current rating of the overload elements applicable to each motor and shall certify it to be correct for all motors before supplying the elements to the job.

C. Submit 3 copies of the certified list for review and permanent record to be referred to in the event of failure of any motor either within or beyond expiration of the warranty period.

3.02 FACTORY TESTING

A. The following standard factory tests shall be performed on the equipment provided under this section. All tests shall be in accordance with the latest version of UL and NEMA standards.

1. All printed circuit boards shall be functionally tested via fault finder bench equipment prior to unit installation

2. All final assemblies shall be load tested.

B. The manufacturer shall provide three (3) certified copies of factory test reports.

3.03 INSTALLATION

A. Mount controllers to maintain code required clearance around controller.

B. Mounting hardware shall be corrosion resistant type.
3.04 FIELD QUALITY CONTROL

A. Provide the services of a qualified factory-trained manufacturer's representative to assist the Design Builder in installation and start-up of the equipment specified under this section. The manufacturer's representative shall provide technical direction and assistance to the Design Builder in general assembly of the equipment, connections and adjustments, and testing of the assembly and components contained herein.

B. The following minimum work shall be performed by the Design Builder under the technical direction of the manufacturer's service representative.

1. Inspection and final adjustments
2. Operational and functional checks of controllers/starters and spare parts.

C. The Design Builder shall provide three (3) copies of the manufacturer's field start-up report.

3.05 FIELD ADJUSTMENTS

3.06 FIELD TESTING

3.07 MANUFACTURER'S CERTIFICATION

A. A qualified factory-trained manufacturer's representative shall certify in writing that the equipment has been installed, adjusted and tested in accordance with the manufacturer's recommendations.

B. The Design Builder shall provide three (3) copies of the manufacturer's representative's certification.

END OF SECTION
<table>
<thead>
<tr>
<th>No.</th>
<th>Name</th>
<th>Scope</th>
<th>Equipment</th>
<th>MFR Model</th>
<th>Serial No. (Year)</th>
<th>Volt/Ph</th>
<th>MCA</th>
<th>MFS</th>
<th>MOCP</th>
<th>Footprint</th>
<th>Curb</th>
<th>Pad</th>
<th>Sleepers</th>
<th>Field Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>MUSIC</td>
<td>Replace (E) 30-ton air-cooled reciprocating chiller with (N) packaged air-cooled scroll chiller</td>
<td>Chiller</td>
<td>007</td>
<td>Carrier 3GA030 S30</td>
<td>596491 (1985)</td>
<td>208-230/3</td>
<td>275</td>
<td>8.2; RLA = 119, LRA = 596, FLA 6.2/1Ω, FLA 6.6/3Ω; Chiller enclosure inside dims: 23’x160”</td>
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<tr>
<td>9</td>
<td>MUSIC</td>
<td>Replace (E) pumps with new pumps with VFD’s</td>
<td>CHWP-1, 2</td>
<td>n/a</td>
<td>Amtrol 1-1/2 x 2 x 7</td>
<td>2009708 (1985)</td>
<td>208-230/3</td>
<td>1/4 HP, 68 gpm at 30’ head, 5.5” impeller</td>
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<td>Building No.</td>
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<td>Curb</td>
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<tr>
<td>11</td>
<td>Kin</td>
<td>Replace (3) pumps with new pumps w/VFD's</td>
<td>CHWP</td>
<td>B&amp;G 1531 21-288/91/4B</td>
<td>941666 (1987)</td>
<td>208/3</td>
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<td></td>
<td>580 gpm @ 80' head; 4&quot; CHW pipe; 7.5 HP</td>
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<td>Kin</td>
<td>Replace (3) 64-tons air-cooled chiller with new packaged air-cooled scroll chiller</td>
<td>C-1</td>
<td>Carrier 30G510 054</td>
<td>(1987)</td>
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<td>134&quot; x 92&quot;</td>
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<td>3&quot; CHW pipe; 36&quot;-42&quot; clearances to enclosure inside walls; no disconnect within sight of chiller.</td>
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<td>11</td>
<td>Kin</td>
<td>Replace existing pneumatic control w/DDC</td>
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<td>Chiller, Boiler and pumps are DDC controlled. OSA lockout. Pumps S/S, Status, CHWS Temp, No HHWS/R Temp, Pump runtime. AHU-4,5 &amp; EF-1: S/S, Status, Economizer, RAT, SAT, HTG &amp; CLG St. Pt., OAT, RT.</td>
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<td>12</td>
<td>LHS Replace (E) 250-ton blow-through counterflow cooling tower with (N) 175-ton variable speed cooling tower</td>
<td>CT-1</td>
<td>106</td>
<td>BAC VFD-N22001MC</td>
<td>94200744 (1994)</td>
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<tr>
<td>12</td>
<td>LHS Replace (E) 250-ton water-cooled screw chiller with (N) 175-ton water-cooled, friction-less centrifugal chiller</td>
<td>Chiller C-1</td>
<td>105</td>
<td>Bohn HWSC-2708</td>
<td>BNK 5007 (1987)</td>
<td>460/3</td>
<td>370</td>
<td>450</td>
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<td></td>
<td>R-22; Main Breaker = 800A; Breaker for chiller = 450A; Breaker for CT fan = 40A; Breakers for (2) CHW pumps = 40A each; Breaker for CT pump = 20A</td>
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<tr>
<td>12</td>
<td>LHS Replace (E) pumps with new pumps with VFD's</td>
<td>CT Pump</td>
<td>n/a</td>
<td>B&amp;G 1511-5BE-91/48F</td>
<td>(1994)</td>
<td>460/3</td>
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<td>750 gpm @ 75'; 20 HP, 1760 rpm</td>
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<td>12</td>
<td>LHS Replace (E) pumps with new pumps with VFD's</td>
<td>CHW Pumps</td>
<td>n/a</td>
<td>Paco 11-30121-146201</td>
<td>HKN14431 (1987)</td>
<td>460/3</td>
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<td>500 gpm @ 97'; 15 HP</td>
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**Campus:** Diablo Valley College (DVC)

**FIELD SURVEY**
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<th>No.</th>
<th>Name</th>
<th>Equip Tag</th>
<th>NAM Tag</th>
<th>MFR Model</th>
<th>Serial No. (Year)</th>
<th>Volt/Ph</th>
<th>MCA</th>
<th>FPS</th>
<th>MOCP</th>
<th>Footprint</th>
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<th>Field Notes</th>
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<td>Suspended unit in ceiling.</td>
</tr>
<tr>
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<td>Suspended unit in ceiling and light to waffle slab beam; 5A outlet collars = (2) 1/8”x19.5” DD; unit in VA.</td>
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<td></td>
<td>33”Wx36”Lx14”H</td>
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<td>Suspended unit; 1/8 HP 2.4A motor; heating coil at 24x12 discharge grille; bottom RA grille with filter</td>
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<td>LIB</td>
<td>AC-5</td>
<td>069</td>
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<td>Nameplate not visible, hidden by duct; also tagged AC-11A; Carrier 40RS016 per as-built schedule</td>
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<td>1 HP; unit on base frame and isolators, but no seismic; also tagged AC-11B</td>
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<td>1 HP; AC-9 on dwg. M-3 dated 1968</td>
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<td>Original plenum supply fan, disabled and abandoned in place.</td>
</tr>
<tr>
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<td>Original plenum supply fan, not upgraded to Reznor.</td>
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<tr>
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<td>There are 2 types of noise that can be heard from inside the library. One is high velocity air noise through the supply diffusers, which is particularly noticeable near the main lobby. The second is the fan and motor noise from the Reznor units on the roof.</td>
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<tr>
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<td>At open duct of the Reznor units into mech penthouse plenum, liner is visibly fraying and needs replacement.</td>
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<td>10 HP; 10,000 cfm at 1.6” max; rubber-in-shear isolators on sleepers; excessive roof vibration</td>
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<td>7.5 HP, 10A motor; 10,000 cfm at 1.6” max.</td>
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<td>5.0 HP, 7.5A motor; 7,000 cfm at 1.6”w.c. max EPM</td>
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<td>39.5”Lx51”W</td>
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<td>7.5 HP; Mounted on two sleepers with rubber-in-shear isolators; Field fabricated economizer</td>
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<td>MFS</td>
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<td>Footprint</td>
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<td>Replace (E) fan coil unit with VAV reheat system; rebalance airside</td>
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<td>Replace (E) fan coil unit with VAV reheat system; rebalance airside</td>
<td>AC-10</td>
<td>067</td>
<td>(1968)</td>
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<td>Replace (E) fan coil unit with VAV reheat system; rebalance airside</td>
<td>AC-1</td>
<td>068</td>
<td>(1968)</td>
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<tr>
<td>57</td>
<td>LIB</td>
<td>Replace existing pneumatic control with DDC</td>
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Campus: Diablo Valley College (DVC)
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<th>Field Notes</th>
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<tr>
<td>S2</td>
<td>PS</td>
<td>Replace existing pneumatic control with DDC</td>
<td>(3) AHU’s (Packaged Rooftop AC units, Single duct VAV with reheat, SF/RF VFD, no VFD on AHU-3. S/S, Status, Speed, Alarm, Runtime, SAT reset. OAD position (AHU-3 only). Run time. AHU-2 serves the 2nd floor labs, and they are all Phoenix valves. Boiler with one pump, HWS/R Temp. OA lockout, DP, ON/OFF, HWS setpoint, Gas detection. EF-1&amp;2 lab exhaust fan, VFD (EF-1 only), Plenum static setpoint and setback, Make up air damper. EF-2 is constant volume. Control air comes from the LHS/PSB central plant.</td>
<td></td>
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</table>
APPENDIX B

EXISTING EQUIPMENT INFORMATION

**Note:** Not all equipment information or original submittals are available.
Installation, Start-Up and Service Instructions

CONTENTS

SAFETY CONSIDERATIONS ............................................. 1
General .............................................................. 1
Job Data ........................................................... 1
RECEIVING AND INSTALLATION ............................. 1-10
Step 1 — Check Equipment .................................. 1
  • IDENTIFY MACHINE
  • INSPECT SHIPMENT
Step 2 — Provide Unit Support ......................... 4
  • ROOF CURB
  • SLAB MOUNT
Step 3 — Provide Clearances ......................... 4
Step 4 — Rig and Place Unit .......................... 4
Step 5 — Connect Condensate Drain .............. 5
Step 6 — Install Venting ............................... 6
Step 7 — Install Gas Piping ......................... 6
Step 8 — Install Duct Connections .............. 7
Step 9 — Install Electrical Connections .......... 8
  • HIGH VOLTAGE CONNECTIONS
  • SPECIAL PROCEDURES FOR 208-V
    OPERATION
  • CONTROL VOLTAGE CONNECTIONS
  • HEAT ANTICIPATOR SETTING
  • TRANSFORMER CIRCUIT PROTECTION
PRE-START-UP .................................................. 10,11
START-UP ....................................................... 11-20
MAINTENANCE .................................................. 20-26

NOTE TO INSTALLER — Before the installation, READ
THESE INSTRUCTIONS CAREFULLY AND COMPLETELY. Also, make sure the User’s Manual and
Replacement Guide are left with the unit after installation.

SAFETY CONSIDERATIONS

Installation and servicing of air conditioning equipment
can be hazardous due to system pressure and electrical components. Only trained and qualified personnel should install, repair or service air conditioning equipment.

Untrained personnel can perform basic maintenance functions of cleaning coils and filters. All other operations should be performed by trained service personnel. When working on air conditioning equipment, observe precautions in the literature, tags and labels attached to the unit and other safety precautions that may apply.

Follow all safety codes. Wear safety glasses and work gloves. Use quenching cloth for unbrazing operations. Have fire extinguisher available for all brazing operations.

WARNING

Improper installation, adjustment, alteration, service, maintenance or use can cause carbon monoxide poisoning, fire or an explosion which can result in personal injury or unit damage. Consult a qualified installer, service agency or gas supplier for information or assistance. The qualified installer or agency must use only factory-authorized kits or accessories when modifying this product.

WARNING

Before performing service or maintenance operations on unit, turn off unit main power switch. Electrical shock could cause personal injury.

General — The 48NLT, NMT, NET, NHT and NVT units are fully self-contained, combination gas heating/cooling units designed for outdoor installation. See Fig. 1. The units are shipped in a vertical configuration and may be installed either on a rooftop or converted to horizontal configuration when placed on a ground-level cement slab.

Job Data — Necessary information consists of: machine location drawings, piping drawings, field wiring diagrams and rigging guide.

RECEIVING AND INSTALLATION

Step 1 — Check Equipment

IDENTIFY MACHINE — The machine model number and serial number are stamped on machine identification plate. Check this information against shipping papers and job data.

INSPECT SHIPMENT — Inspect for shipping damage while machine is still on shipping pallet. If machine appears to be damaged or is torn loose from its anchorage, have it examined by transportation inspectors before removal. Forward claim papers directly to transportation company. Manufacturer is not responsible for any damage incurred in transit.

Check all items against shipping list. Immediately notify the nearest Carrier Air Conditioning office if any item is missing.

To prevent loss or damage, leave all parts in original packages until installation.
### Table 1 — Physical Data

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</tbody>
</table>

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**Operating charge is listed on unit nameplate.

†Required field-supplied filter areas are based on the larger of the ARI-rated (Air Conditioning & Refrigeration Institute) cooling airflow or the heating airflow at a velocity of 300 ft/min for disposable type or 450 ft/min for high-capacity type. Air filter pressure drop must not exceed 0.08 in. w.g.

**Single-phase units

††Three-phase units

---

**Step 2 — Provide Unit Support**

**ROOF CURB** — Install accessory roof curb in accordance with instructions shipped with curb. Install insulation, cant strips, roofing and flashing. Ductwork must be attached to curb.

**IMPORTANT:** The gasketing of the unit to the roof curb is critical for water integrity. Install gasketing material supplied with the roof curb. Improperly applied gasketing also can result in air leaks and poor unit performance.

Curb should be level to within 1/4 inch. This is necessary for unit drain to function properly. Refer to Accessory Roof Curb Installation Instructions for additional information as required.

**SLAB MOUNT** — Place the unit on a solid, level concrete pad that is a minimum of 4-in. thick with 2-in. above grade. The slab should extend approximately 2-in. beyond the casing on all 4 sides of the unit. Install a gravel apron in front of condenser-air inlets to prevent obstruction of airflow by grass or shrubs. Do not secure the unit to the slab except when required by local codes.

**Step 3 — Provide Clearances** — The required minimum operating and service clearances are shown in Fig. 2 and 3. Adequate combustion, ventilation and condenser air must be provided.

The condenser fan discharges through the top of the unit. Be sure that the fan discharge does not recirculate to the condenser coil. Do not locate the unit in either a corner or under an overhead obstruction. The minimum clearance under a partial overhang (such as a normal house overhang) is 48-in. above the unit top. The maximum horizontal extension of a partial overhang must not exceed 48 inches.

---

**CAUTION**

Do not restrict condenser airflow. An air restriction at either the outdoor-air inlet (the entire surface of the outdoor coil) or the fan discharge can be detrimental to compressor life.

Do not place the unit where water, ice or snow from an overhang or roof will damage or flood the unit. Do not install the unit on carpeting, tile or other combustible materials. The unit may be installed on wood flooring or on Class A, B or C roof covering materials.

**Step 4 — Rig and Place Unit** — Use spreader bars and crate top when rigging the unit. The units must be rigged for lifting as shown in Fig. 4. Refer to Fig. 4 for rigging weight and Table 1 for operating weight. Use extreme caution to prevent damage when moving the unit. Unit must remain in an upright position during all rigging and moving operations. The unit must be level for proper condensate drainage; therefore, the ground-level pad or accessory roof-mounting curb must be level before setting the unit in place. When a field-fabricated support is used, be sure that the support is level and properly supports the unit.

---

**CAUTION**

When installing the unit on a rooftop, be sure the roof will support the additional weight. Refer to Fig. 4 for corner weight information.
Table 1 – Physical Data (cont)

<table>
<thead>
<tr>
<th>UNIT SIZE 48</th>
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<th>NET 042</th>
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<tr>
<td>OPERATING WEIGHT (lb)</td>
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**COMPRESSORS**

Quantity: 1

Refrigerant: R-22

Refrigerant metering device: AccuRate® Piston

**CONDENSER COIL**

Rows: 2

Fins/in.: 20

Condenser fan: 2500 | 3000 | 1100 | 3500 | 1 | 20 |

Motor Hp (single-phase): 1/2

Motor Hp (three-phase): 1/4

**EVAPORATOR COIL**

Rows: 3

Fins/in.: 14

Evaporator fan: 1400 | 2000 |

Motor Hp (single-phase): 1/2

Motor Hp (three-phase): 1/4

**FURNACE SECTION**

Burner Orifice No. (Gt...drl size): Natural Gas

Burner Orifice No. (Gt...drl size): Propane Gas

Pilot Orifice Diameter (In...drl size): Natural Gas

Pilot Orifice Diameter (In...drl size): Propane Gas

<p>| | | | |</p>
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<tr>
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<td>56</td>
<td>6</td>
<td>54</td>
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</tbody>
</table>

**RETURN-AIR FILTERS (sq in.):**

Disposable: 720

Cleanable: 480

**Fig. 4 – Suggested Rigging**

---

**Step 5 – Connect Condensate Drain**

NOTE: When installing condensate drain connection be sure to comply with local codes and restrictions.

The unit disposes of condensate water through a ¾-in. NPT drain fitting. See Fig. 2 and 3 for location.

Install a 2-in. trap at the drain fitting to ensure proper drainage. See Fig. 5. Make sure the outlet of the trap is at least one-in. lower than the unit drain pan connection to prevent the pan from overflowing. Prime the trap with water.

If the installation requires draining the condensate water away from the unit, connect a drain tube using a minimum of ¾-in. OD copper tubing, ¼-in. galvanized pipe or ¾-in. plastic pipe. *Do not undersize the tube.* Pitch the drain tube downward at a slope of at least one inch in every 10 ft of horizontal run. Be sure to check the drain tube for leaks.
Condensate water can be drained directly onto the roof in rooftop installations (where permitted) or onto a gravel apron in ground-level installations. When using a gravel apron, make sure it slopes away from the unit.

**Step 6 — Install Venting** — The vent cap assembly is shipped in the burner compartment. Remove the access door to locate the assembly.

**CAUTION**

The venting system is designed to ensure proper venting. The vent cap assembly must be installed as indicated in this section of the unit Installation Instructions.

NOTE: Screw holes in the flue assembly and the unit flue panel are not symmetrically located. Make sure they are oriented properly when installing these components.

Refer to Fig. 6 and install the vent cap as follows:

1. Place vent cap assembly over flue panel. Orient screw holes in vent cap with holes in flue panel.

![Fig. 6 — Vent Cap Assembly](image)

2. Secure vent cap in place by inserting the single screw on the right side of vent cap.
3. Place the vent cap guard over the vent cap. Orient holes in vent cap guard with holes in vent cap and flue panel.
4. Secure the entire assembly with the remaining 2 screws on the left side of vent cap and vent-cap guard assembly.

**Step 7 — Install Gas Piping** — The gas supply pipe enters the unit through the access hole provided. The gas connection to the unit is made to the ½-in. FPT gas inlet on the manual shutoff or gas valve.

Install a separate gas supply line that runs directly from the meter to the heating section. Refer to Table 2 and the National Fuel Gas Code (NFGC) for gas pipe sizing. Do not use cast-iron pipe. It is recommended that black iron pipe is used. Check the local utility for recommendations concerning existing lines. Choose a supply pipe that is large enough to keep the pressure loss as low as practical. Never use pipe smaller than the ½-in. FPT gas inlet on the unit gas valve.

For natural gas applications, the gas pressure at unit gas connection must not be less than 5 in. wg or greater than 13 in. wg while the unit is operating. For propane applications, the gas pressure must not be less than 11 in. wg or greater than 13 in. wg at the unit connection.

When installing the gas supply line, observe local codes pertaining to gas pipe installations. Refer to the NFGC ANSI (American National Standards Institute) Z223.1-1988 NFPA (National Fire Protection Association) 54-1988 (in Canada, CAN/CGA [Canadian Gas Association] B149.1, (2)-M86). In the absence of local building codes, adhere to the following pertinent recommendations:

1. Avoid low spots in long runs of pipe. Grade all pipe ¼ inch in every 15 ft to prevent traps. Grade all horizontal runs downward to risers. Use risers to connect to heating section and to meter.
2. Protect all segments of piping system against physical and thermal damage. Support all piping with appropriate straps, hangers, etc. Use a minimum of one hanger every 6 ft. For pipe sizes larger than ½ in., follow recommendations of national codes.
3. Apply joint compound (pipe dope) sparingly and only to male threads of joint when making pipe connections. Use only pipe dope that is resistant to action of liquefied petroleum gases as specified by local and/or national codes. Never use Teflon tape.
4. Install sediment trap in riser leading to heating section. This drip leg functions as a trap for dirt and condensate. Install trap where condensate cannot freeze. Install this sediment trap by connecting a piping tee to riser leading to heating section, so that straight-through section of tee is vertical. See Fig. 7. Then, connect capped nipple into lower end of tee. Extend capped nipple below level of gas controls.

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<th>30</th>
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<td>500</td>
<td>460</td>
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*Capacity of pipe in cu ft of gas per hr for gas pressure of 0.5 psig or less. Pressure drop of 0.5 in. wg (based on a 0.60 specific gravity gas). Refer to Table C-4, NFPA 54-1984
†This length includes an ordinary number of fittings.
testing of the piping systems when test pressure in excess of 0.5 psig. Pressure test the gas supply piping system at pressures equal to or less than 0.5 psig. The unit heating section must be isolated from the gas piping system by closing the external main manual shutoff valve and slightly opening the ground-joint union.

⚠️ CAUTION

Unstable operation may occur when the gas valve and manifold assembly are forced out of position while connecting improperly-routed rigid gas piping to the gas valve. Use a backup wrench when making connection to avoid strain on, or distortion of, the gas control piping.

⚠️ CAUTION

If a flexible conductor is required or allowed by the authority having jurisdiction, black iron pipe shall be installed at the gas valve and shall extend a minimum of 2 in. outside the unit casing.

⚠️ WARNING

Never use a match or other open flame when checking for gas leaks. Never purge gas line into combustion chamber. Failure to follow this warning could result in an explosion causing personal injury or death.

8. Check for gas leaks at the field-installed and factory-installed gas lines after all piping connections have been completed. Use soap-and-water solution (or method specified by local codes and/or regulations).

Step 8 — Install Duct Connections — The unit has duct flanges on the supply- and return-air openings on the side and bottom of the unit. See Fig. 2 and 3 for connection sizes and locations.

NOTE: The design and installation of the duct system must be in accordance with the standards of the NFPA for installation of nonresidence-type air conditioning and ventilating systems, NFPA No. 90A or residence-type, NFPA No. 90B; and/or local codes and residence-type, NFPA No. 90B; and/or local codes and ordinances.

Adhere to the following criteria when selecting, sizing and installing the duct system:

1. The unit is shipped in vertical configuration. To convert unit to horizontal application, remove side duct covers, save screws and install the covers on bottom duct openings.

2. Select and size ductwork, supply-air registers and return-air grilles according to ASHRAE (American Society of Heating, Refrigeration and Air Conditioning Engineers) recommendations.

⚠️ CAUTION

When drilling the duct-system fastening holes into the side of the unit instead of the unit duct flanges, use extreme care to avoid puncturing the coil or coil tubes. See Fig. 8.

5. Install an accessible, external, manual main shutoff valve in gas supply pipe within 6 ft of heating section.
6. Install ground-joint union close to heating section between unit manual shutoff and external manual main shutoff valve.
7. Pressure-test all gas piping in accordance with local and national plumbing and gas codes before connecting piping to unit.

NOTE: Pressure test the gas supply system after the gas supply piping is connected to the gas valve. The supply piping must be disconnected from the gas valve during the

---

Fig. 8 — Location of Coil Area Not to be Drilled

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<th>Size</th>
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<tr>
<td>Large Cabinet</td>
<td>NHT036—NVT060</td>
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</tbody>
</table>

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3. Use flexible transition between rigid ductwork and unit to prevent transmission of vibration. The transition may be screwed or bolted to duct flanges. Use suitable gaskets to ensure weather- and airtight seal.

4. Install external, field-supplied air filter(s) in return-air ductwork where it is easily accessible for service. Recommended filter sizes are shown in Table 1.

5. Size all ductwork for maximum required airflow (either heating or cooling) for unit being installed. Avoid abrupt duct size increases or decreases.

6. Adequately insulate and weatherproof all ductwork located outdoors. Insulate ducts passing through unconditioned space, and use vapor barrier in accordance with latest issue of SMACNA (Sheet Metal and Air Conditioning Contractors National Association) and ACCA (Air Conditioning Contractors of America) minimum installation standards for heating and air conditioning systems. Secure all ducts to building structure.

7. Flash, weatherproof and vibration-isolate all openings in building structure in accordance with local codes and good building practices.

**Step 9 — Install Electrical Connections**

<table>
<thead>
<tr>
<th>WARNING</th>
</tr>
</thead>
<tbody>
<tr>
<td>The unit cabinet must have an uninterrupted, unbroken electrical ground to minimize the possibility of personal injury if an electrical fault should occur. This ground may consist of an electrical wire connected to the unit ground lug in the control compartment, or conduit approved for electrical ground when installed in accordance with NEC (National Electrical Code) ANSI/NFPA (latest edition) (in Canada, Canadian Electrical Code CSA C22.1) and local electrical codes. Do not use gas piping as an electrical ground. Failure to adhere to this warning could result in personal injury or death.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CAUTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Failure to follow these precautions could result in damage to the unit being installed:</td>
</tr>
</tbody>
</table>

1. Make all electrical connections in accordance with NEC ANSI/NFPA (latest edition) and local electrical codes governing such wiring. In Canada, all electrical connections must be in accordance with CSA Standard C22.1 Canadian Electrical Code Part 1 and applicable local codes. Refer to unit wiring diagram.

2. Use only copper conductor for connections between field-supplied electrical disconnect switch and unit. DO NOT USE ALUMINUM WIRE.

3. Be sure that high-voltage power to unit is within operating voltage range indicated on unit rating plate. On 3-phase units, ensure that phases are balanced within 2%. Consult local power company for correction of improper voltage and/or phase balance.

4. Insulate low-voltage wires for highest voltage contained within conduit when low-voltage control wires are run in same conduit as high-voltage wires.

5. Do not damage internal components when drilling through any panel to mount electrical hardware, conduit, etc.

**HIGH-VOLTAGE CONNECTIONS —** The unit must have a separate electrical service with a field-supplied, waterproof, fused disconnect switch mounted at, or within sight from, the unit. Refer to the unit rating plate for maximum fuse/circuit breaker size and minimum circuit amps (ampacity) for wire sizing. See Table 3 for electrical data. The field-supplied disconnect switch box may be mounted on the unit over the high-voltage inlet hole in the control corner panel. See Fig. 2 and 3.

Proceed as follows to complete the high-voltage connections to the unit:

1. Connect ground lead to chassis ground connection when using separate ground wire.

2. Run high-voltage leads into unit control box and connect to contactor. See unit wiring label, and Fig. 9.

<table>
<thead>
<tr>
<th>CAUTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRANSFORMER CONTAINS AUTO RESET OVERCURRENT PROTECTOR.</td>
</tr>
</tbody>
</table>

**IT MAY RESET WITHOUT WARNING STARTING HEATING OR COOLING SECTION OF THIS PRODUCT.**

**DISCONNECT POWER PRIOR TO SERVICING.**

**THIS COMPARTMENT MUST BE CLOSED EXCEPT WHEN SERVICING.**

**316056-201 REV A**

**Fig. 9 — Transformer Label**
### Table 3 – Electrical Data

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</table>

**AWG** = American Wire Gauge  
**FLA** = Full Load Amps  
**LRA** = Locked Rotor Amps  
**MCA** = Minimum Circuit Amps  
**MOCP** = Maximum Overcurrent Protection  
**NEC** = National Electrical Code  
**RLA** = Rated Load Amps

**NOTES:**
1. In compliance with NEC requirements for multimotor and combination load and equipment (refer to NEC Articles 430 and 440), the overcurrent protective device for the unit shall be fuse or HACP breaker.
2. **Unbalanced 3-Phase Supply Voltage**
   - Never operate a motor where a phase imbalance in supply voltage is greater than 2%. Use the following formula to determine the % voltage imbalance:
   
   \[ \text{% Voltage Imbalance} = \frac{\text{max voltage deviation from average voltage}}{\text{average voltage}} \times 100 \]

   **Example:** Supply voltage is 460-3-60
   - AB = 452 volts  
   - BC = 464 volts  
   - AC = 455 volts
   - Average Voltage = \( \frac{452 + 464 + 455}{3} = \frac{1371}{3} = 457 \) volts

Determine maximum deviation from average voltage:
- (AB) 457 – 452 = 5 volts  
- (BC) 464 – 457 = 7 volts  
- (AC) 457 – 456 = 2 volts

Maximum deviation is 7 volts. Determine % voltage imbalance:

\[ \% \text{Voltage Imbalance} = 100 \times \frac{7}{457} \approx 1.53\% \]

This amount of phase imbalance is satisfactory as it is below the maximum allowable 2%.

**IMPORTANT:** If the supply voltage phase imbalance is more than 2%, contact your local electric utility company immediately.
SPECIAL PROCEDURES FOR 208-V OPERATION

⚠️ WARNING
Make sure that the power supply to the unit is switched OFF before making any wiring changes. Electrical shock can cause personal injury or death.

1. Disconnect the orange transformer-primary lead from the contactor. See unit wiring label.
2. Remove the tape and cover from the terminal on the end of the red transformer-primary lead.
3. Save the cover.
4. Connect the red lead to the contactor terminal from which the orange lead was disconnected.
5. Using the cover removed from the red lead, insulate the loose terminal on the orange lead.
6. Wrap the cover with electrical tape so that the metal terminal cannot be seen.

Indoor blower motor speeds should be changed for 208-v operation. In the unit control box, change motor leads on the printed circuit board so that high speed is used for cooling and medium speed is used for heating. Do not change blower speed setting for 460-v rated units. Refer to Start-Up, Indoor Airflow and Airflow Adjustments section.

CONTROL VOLTAGE CONNECTIONS — Locate the room thermostat on an inside wall in the space to be conditioned, where it will not be subjected to either a cooling or heating source or direct exposure to sunlight. Mount the thermostat 4 to 5 ft above the floor.

Use no. 18 American Wire Gage (AWG) color-coded, insulated (35 C minimum) wires to make the control voltage connections between the thermostat and the unit. If the thermostat is located more than 100 ft from the unit (as measured along the control voltage wires), use no. 16 AWG color-coded, insulated (35 C minimum) wires.

A grommeted, control voltage inlet hole is located in the panel adjacent to the control access panel. Run the low-voltage leads from the thermostat, through the inlet hole, and to the control voltage terminals through a hole in the bottom of the unit control box. Pass control voltage leads through wire ties located under unit control box. Connect the thermostat leads to the terminals as shown in Fig. 10.

HEAT ANTICIPATOR SETTING — The room thermostat heat anticipator must be adjusted properly to ensure proper heating performance. Set the heat anticipator, using an ammeter between the W and R terminals to determine the exact required setting.

NOTE: For thermostat selection purposes, use 0.6 amp for the approximate required setting.

Failure to make a proper heat anticipator adjustment will result in improper operation, discomfort to the occupants of the conditioned space and inefficient energy utilization; however, the required setting may be changed slightly to provide a greater degree of comfort for a particular installation.

TRANSFORMER CIRCUIT PROTECTION — The unit transformer contains an auto. reset overcurrent protector for control circuit protection. If this device trips, it may reset without warning, starting the heating or cooling section of this product. Use caution when servicing; if overcurrent protector continues to trip, there is a problem in the low-voltage electrical circuit, such as an electrical short, ground or transformer overload. Disconnect power, correct the condition, and check for normal unit operation.

PRE-START-UP

⚠️ WARNING
Failure to observe the following warnings could result in serious personal injury:

1. Follow recognized safety practices and wear protective goggles when checking or servicing refrigerant system.
2. Do not operate compressor or provide any electric power to unit unless compressor terminal cover is in place and secured.
3. Do not remove compressor terminal cover until all electrical sources are disconnected.
4. Relieve all pressure from system before touching or disturbing anything inside terminal box if refrigerant leak is suspected around compressor terminals.
5. Never attempt to repair soldered connection while refrigerant system is under pressure.
6. Do not use torch to remove any component. System contains oil and refrigerant under pressure. To remove a component, wear protective goggles and proceed as follows:
   a. Shut off gas supply and then electrical power to unit.
   b. Relieve all pressure from system using both high- and low-pressure ports.
   c. Cut component connecting tubing with tubing cutter and remove component from unit.
   d. Carefully unsweat remaining tubing stubs when necessary. Oil can ignite when exposed to torch flame.

   Proceed as follows to inspect and prepare the unit for initial start-up:
1. Remove all access panels.
2. Read and follow instructions on all WARNING, CAUTION and INFORMATION labels attached to, or shipped with, unit.

Make the following inspections:
   a. Inspect for shipping and handling damages such as broken lines, loose parts, disconnected wires, etc.
   b. Inspect for oil at all refrigerant tubing connections and on unit base. Detecting oil generally indicates
a refrigerant leak. Leak-test all refrigerant tubing connections using electronic leak detector, or liquid-soap solution. If a refrigerant leak is detected, see Start-Up, Check for Refrigerant Leaks section.

c. Inspect all field- and factory-wiring connections. Be sure that connections are completed and tight.

d. Inspect coil fins. If damaged during shipping and handling, carefully straighten fins with a fin comb.

3. Verify the following conditions:

**WARNING**

Do not purge gas supply into the combustion chamber. Do not use a match or other open flame to check for gas leaks. Failure to follow this warning could result in an explosion causing personal injury or death.

- Make sure that gas supply has been purged, and that all gas piping has been checked for leaks.
- Make sure that outdoor-fan blade is correctly positioned in fan orifice. _Blades should clear fan motor by no more than ¼ inch._
- Make sure that air filter(s) is in place.
- Make sure that condensate drain pan and trap are filled with water to ensure proper drainage.
- Make sure that all tools and miscellaneous loose parts have been removed.

START-UP

**Check for Refrigerant Leaks** — Proceed as follows to locate and repair a refrigerant leak and to charge the unit:

1. Locate leak and make sure that refrigerant system pressure has been relieved.

2. Repair leak following accepted practices.
   
   NOTE: Install a filter drier whenever the system has been opened for repair.

3. Add a small charge of R-22 refrigerant vapor to system and leak-test unit.

4. Evacuate refrigerant system if additional leaks are not found.

5. Charge unit with R-22 refrigerant, using a volumetric-charging cylinder or accurate scale. _Refer to unit rating plate for required charge._ Be sure to add extra refrigerant to compensate for internal volume of filter drier.

**Start-Up Heating Section and Make Adjustments**

**CAUTION**

Complete the required procedures given in Start-Up section before starting the unit.

Do not jumper any safety devices when operating the unit.

Make sure that burner orifices are aligned properly. Unsteady operation may occur when the burner orifices in the manifold are misaligned.

NOTE: When installing a unit in extremely cold climate areas, a run-in period for the inducer motor is recommended. After the unit is installed, disconnect the red wire from terminal 2 at the ignition control (IGN) and jumper terminals R-W at the control voltage terminal board. The inducer motor should run but the burner will not ignite. Allow inducer motor to run for 4 to 5 hours. Reconnect red wire to terminal 2 at IGN and remove R-W jumper at the control voltage terminal board. Proceed as follows to complete heating section start-up.

Follow the lighting instructions on the heating section operation label (located inside the burner access door) to start the heating section.

When lighting the unit for the first time, perform the following:

If the gas supply pipe was not purged before connecting the unit, it will be full of air. It is recommended that the ground joint union be loosened, and the supply line be allowed to purge until the odor of gas is detected. Never purge gas lines into a combustion chamber. Immediately upon detection of gas odor, retighten the union. Allow 5 minutes to elapse, then light unit using the following steps.

**CHECK HEATING CONTROL** — Start and check the unit for proper heating control operation as follows: (See furnace lighting instructions located inside burner access panel.)

1. Place the room thermostat SYSTEM switch in the HEAT position and the fan switch in the AUTO position.

2. Set the heating temperature control of the thermostat above room temperature.

3. Observe that after built-in time delays, the pilot automatically lights, the burners light and the blower motor starts.

4. Observe that the burners and pilot go out, and that after a built-in delay the blower motor stops when the heating control setting of the thermostat is satisfied.

**NOTE:** The 060-size 460-v models are equipped with a 3-phase blower motor. Check blower wheel for correct rotation as indicated by arrow on blower housing. If blower wheel rotates in opposite direction, reverse any 2 blower motor leads or any 2 line voltage leads. Recheck blower wheel rotation if necessary to reverse leads.

**CHECK GAS INPUT** — Check gas input and manifold pressure after unit start-up. (See Table 4.) If adjustment is required, proceed as follows.

The rated gas inputs shown in Table 4 are for altitudes from sea level up to 2000 ft above sea level. These inputs are based on natural gas with a heating value of 1050 Btu/ft³ at 0.65 specific gravity, or propane gas with a heating value of 2500 Btu/ft³ at 1.5 specific gravity. For elevations above 2000 ft, reduce input 4% for each 1000 ft above sea level. When the gas supply being used has a different heating value or specific gravity, refer to national and local codes, or contact your Distributor or Branch to determine the required orifice size.

**CAUTION**

These units are designed to consume the rated gas inputs using the fixed orifices at specified manifold pressures as shown in Table 4. **DO NOT REDRILL THE ORIFICES UNDER ANY CIRCUMSTANCES.**

**ADJUST GAS INPUT** — The gas input to the unit is determined by measuring the gas flow at the meter or by measuring the manifold pressure. Measuring the gas flow at the meter is recommended for natural gas units. The manifold pressure must be measured to determine the input of propane gas units.

**Measure Gas Flow (Natural Gas Units)** — Minor adjustment to the gas flow can be made by changing the manifold pressure. The manifold pressure must be maintained between 3.2 and 3.8 in. wg. If larger adjustments are required, change main burner orifices following the recommendations of national and local codes.
### Table 4 — Rated Gas Inputs

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<th>NUMBER OF ORIFICES</th>
<th>GAS SUPPLY PRESSURE</th>
<th>MANIFOLD PRESSURE</th>
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<th>PROPANE*</th>
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<td>Propane</td>
<td>Orifice Drill Size</td>
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<td>13.6</td>
<td>11.0</td>
<td>13.6</td>
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*When a 4BN unit is converted to propane, the unit must be modified. See kit instructions.
†Based on altitudes from sea level up to 2000 ft above sea level. For altitudes above 2000 ft, reduce input rating 4% for each 1000 ft above sea level. In Canada, from 2000 ft above sea level to 4500 ft above sea level, derate the unit 10%.

NOTE: All other appliances that use the same meter must be turned off when gas flow is measured at the meter.

Proceed as follows:
1. Turn off gas supply to unit.
2. Remove pipe plug on outlet of gas valve, then connect manometer at this point. Turn on gas to unit.
3. Record number of seconds for gas meter test dial to make one revolution.
4. Divide number of seconds in Step 3 into 3600 (number of seconds in one hour).
5. Multiply result of Step 4 by the number of cu ft shown for one revolution of test dial to obtain cu ft of gas flow per hour.
6. Multiply result of Step 5 by Btu heating value of gas to obtain total measured input in Btu. Compare this value with heating input shown in Table 4. (Consult the local gas supplier if the heating value of gas is not known.)

Example: Assume that the size of test dial is one cu ft, one revolution takes 30 seconds, and the heating value of the gas is 1050 Btu/ft³. Proceed as follows:
1. 30 seconds to complete one revolution.
2. 3600 ÷ 30 = 120.
3. 120 x 1 = 120 ft³ of gas flow/hr.
4. 120 x 1050 = 126,000 Btu/hr input.

If the desired gas input is 125,000 Btu/hr, only a minor change in the manifold pressure is required.

Observe manifold pressure and proceed as follows to adjust gas input:
1. Remove cover screw over regulator adjustment screw on gas valve.
2. Turn regulator adjustment screw clockwise to increase gas input, or turn regulator adjustment screw counterclockwise to decrease input. Manifold pressure must be between 3.2 and 3.8 in. wg.

### A WARNING

Unstable operation of the unit may result if manifold pressure is outside this range. Personal injury or unit damage may result.

3. Replace cover screw cap on gas valve.
4. Turn off gas supply to unit. Remove manometer from pressure tap. Replace pipe plug on gas valve. Turn on gas to unit. Check for leaks.

**Measure Manifold Pressure (Propane Units)** — The main burner orifices on a propane gas unit are sized for the unit rated input when the manifold pressure is 10.5 in. wg.

Proceed as follows to adjust gas input on a propane gas unit:
1. Turn off gas to unit.
2. Remove pipe plug on outlet of gas valve, then connect manometer at this point.
3. Turn on gas to unit.
4. Remove cover screw over regulator adjustment screw on gas valve.
5. Adjust regulator adjustment screw for a manifold pressure reading of 10.5 in. wg. Turn adjusting screw clockwise to increase manifold pressure, or turn adjusting screw counterclockwise to decrease manifold pressure.
6. Replace cover screw.
7. Turn off gas to unit. Remove manometer from pressure tap. Replace pipe plug on gas valve, then turn on gas to unit. Check for leaks.

**CHECK BURNER FLAME** — Observe the unit heating operation, and watch the burner flames through the observation port to see if they are light blue and soft in appearance, and that the flames are approximately the same for each burner. See Fig. 11.

**BLOWER HEAT-RELAY OPERATION** — Blower relay PC1 (see the unit wiring diagram) is located in the control box and adjusts to permit either longer or shorter ‘on’ cycles. The ‘on’ cycle is factory set for one minute on timing. The adjusting dial on the relay (see Fig. 12) is factory set at the minimum position to provide optimum performance for most installations. On unusual installations, the length of time the blower remains on may need to be increased. To increase blower operation time, rotate the adjusting dial counterclockwise. To decrease blower operation time, rotate dial clockwise.

**AIRFLOW AND TEMPERATURE RISE** — The heating section for each size unit is designed and approved for heating operation within the temperature-rise range stamped on the unit rating plate.

Table 5 shows the approved temperature-rise range for each unit, and the air delivery cfm at various temperature rises. The heating operation airflow must produce a temperature rise that falls within the approved range.

Refer to Indoor Airflow and Airflow Adjustments section to adjust heating airflow when required.
SAFETY CHECK OF LIMIT CONTROL — The control shuts off the gas supply and energizes the circulating-air blower motor if the furnace overheats.

The recommended method of checking this limit control is to gradually block off the return air after the furnace has been operating for a period of at least 5 minutes. As soon as the limit control functions, the return-air opening should be unblocked to permit normal air circulation. By using this method to check the limit control, it can be established that the limit is functioning properly and the furnace will “failsafe” if there is a restricted circulating air supply or motor failure. If the limit control does not function during this test, the cause must be determined and corrected.

HEATING SEQUENCE OF OPERATION — See Fig. 13 for single-phase operation and Fig. 14 for 3-phase operation. Room thermostat calls for heat, closing circuit between R and W 24-v control circuit terminals. (Power to the R terminal is supplied through LS and ALS safety switches.) The PC2 inducer control board is energized through the normally closed set of contacts of pressure switches (CPS), which starts the inducer motor (IM). The IM comes up to speed, and the vacuum in the collector box increases, opening the normally closed and closing the normally open contacts of the pressure switch (PS), energizing the circuit to the ignition control (IGN) and the pilot valve (PV). If the flame sensor senses the presence of the pilot flame, the internal switching of the ignition control deenergizes the spark generator and energizes the main gas valve (MV) and the IFR2 electronic timer. Gas flows to the main burners and is ignited by the pilot flame. The PC1 electronic timer will close the IFR2 relay 60 seconds after the burners are ignited and the blower motor (IFM) will start. When the thermostat is satisfied, the R and W circuit is opened and power is removed from the PC2 inducer control and the ignition module (IGN), which causes the MV to close instantly and the IM is deenergized. The electronic timer PC1 will keep the IFM running an additional 60 to 90 seconds. Then the blower stops and the unit is on standby until another call for heat.

NOTE: If the main limit switch opens due to the unit overheating, the IFM is turned on through the electronic board.

NOTE: When the unit is initially powered, IFR2 will close and run the IFM for the duration of the off-delay cycle (60 to 90 seconds).

If the pilot fails to light within a 120-second trial for ignition period from the initial call for heat, the IGN will go into a Retry mode after a period of approximately 5 minutes (following the 2-minute trial for ignition period). If the pilot again fails to light, IGN will go into Retry mode; this cycle will be repeated until the pilot light ignites. If the pilot flame has been established but then extinguishes, the IGN will immediately reset as if it were the initial call for heat. If this occurs more than 3 times, the IGN will lock out the system, and the diagnostic LED (located on the IGN) will flash. To reset, open the R-W thermostat circuit for 30 seconds and reclose. If the diagnostic LED glows constantly, replace control.

LIMIT SWITCHES — Normally closed limit switch LS completes the control circuit through the thermostat R circuit. See Fig. 13 and 14. Should the leaving-air temperature rise above the maximum allowable temperature, the limit switch opens and the R control circuit “breaks.” Any interruption in the R control circuit instantly closes the gas valve and stops gas flow to the burners and pilot. The IFM continues to run until the LS resets.

When the air temperature at the limit switch drops to the low-temperature setting of the limit switch, the switch closes and completes the R control circuit. The electric-spark ignition system cycles and the unit returns to normal heating operation.

BLOWER AUXILIARY LIMIT SWITCH — Blower auxiliary limit switch ALS1 is a temperature-actuated auto-reset switch and is connected in series with the limit switch LS. The function of the switch is to prevent abnormal blower compartment temperatures. The switch is mounted on the blower housing. When the temperature at the auxiliary switch reaches the maximum allowable temperature, the R control circuit “breaks,” closing the gas valve and stopping gas flow to the burners and pilot. The switch will automatically reset when the blower compartment temperature returns to normal. The IFM continues to run until ALS1 resets.

ROLLOUT AUXILIARY LIMIT SWITCH — Rollout auxiliary limit switch ALS2 is a temperature-actuated manual reset switch connected in series with limit switch LS and blower auxiliary limit switch ALS1. The function of the switch is to close the main gas valve in the event of flame rollout. The switch is located above the main burners. When the temperature at the auxiliary switch reaches the maximum allowable temperature, the R control circuit trips, closing the gas valve and stopping gas flow to the burners and pilot. To reset the switch, push in the red button. If the switch cycles again, shut down the unit and call for service. The IFM continues to run until ALS2 is reset.
Fig. 13 — Typical Single-Phase Wiring Diagram
Start-Up Cooling Section and Make Adjustments

⚠️ CAUTION ⚠️
Complete the required procedures given in the Pre-Start-Up section before starting the unit.
Do not jumper any safety devices when operating the unit.
Do not operate the compressor when the outdoor temperature is below 55°F (unless accessory low-temperature kit is installed).
Do not rapid-cycle the compressor. Allow 5 minutes between “on” cycles to prevent compressor damage.

CHECKING COOLING CONTROL OPERATION — Start and check the unit for proper cooling control operation as follows:

1. Place room thermostat SYSTEM switch in OFF position. Observe that blower motor starts when FAN switch is placed in ON position and shuts down when FAN switch is placed in AUTO. position.

2. Place SYSTEM switch in COOL position and FAN switch in AUTO. position. Set cooling control below room temperature. Observe that compressor, condenser fan and evaporator blower motors start. Observe that cooling cycle shuts down when control setting is satisfied. The blower motor has an off delay of approximately one minute on shutdown.

3. When using an auto.-changeover room thermostat, place both SYSTEM and FAN switches in AUTO. positions. Observe that unit operates in heating mode when temperature control is set to “call for heating” (above room temperature) and operates in cooling mode when temperature control is set to “call for cooling” (below room temperature).

CHECKING AND ADJUSTING REFRIGERANT CHARGE — The refrigerant system is fully charged with R-22 refrigerant, tested and factory-sealed.

NOTE: Adjustment of the refrigerant charge is not required unless the unit is suspected of not having the proper R-22 charge. For all applications, the correct R-22 charge for the best performance is the charge that results in a suction gas superheat of 5°F at the compressor inlet when the unit is operating at the ARI rating conditions of 95°F dry-bulb (db) outdoor and 80°F db/67°F wet-bulb (wb) indoor.

A superheat charging label is attached to the outside of the compressor access door. The label includes a “Superheat Charging Table” and a “Required Suction-Tube Temperature (F)” chart.

An accurate superheat thermocouple- or thermistor-type thermometer, a sling psychrometer and a gage manifold are required when using the superheat charging method for evaluating the unit charge. Do not use mercury or small dial-type thermometers because they are not adequate for this type of measurement.

⚠️ CAUTION ⚠️
When evaluating the refrigerant charge, an indicated adjustment to the specified factory charge must always be very minimal. If a substantial adjustment is indicated, an abnormal condition exists somewhere in the cooling system, such as insufficient airflow across either coil or both coils.

Proceed as follows:
1. Remove caps from low- and high-pressure service fittings.
2. Using hoses with valve core depressors, attach low- and high-pressure gage hoses to low- and high-pressure service fittings, respectively.
3. Start unit in cooling mode and let unit run until system pressures stabilize.
4. Measure and record the following:
   a. Outdoor ambient-air temperature (F db).
   b. Evaporator inlet-air temperature (F wb).
   c. Suction-tube temperature (F) at low-side service fitting.
   d. Suction (low-side) pressure (psig).
5. Using “Superheat Charging Table,” compare outdoor-air temperature (F db) with evaporator inlet-air temperature (F wb) to determine desired system operating superheat temperature. See Table 6.
6. Using “Required Suction-Tube Temperature (F)” table, compare desired superheat temperature with suction (low-side) operating pressure (psig) to determine proper suction-tube temperature. See Table 7.
7. Compare actual suction-tube temperature with proper suction-tube temperature. Using a tolerance of ± 3°F, add refrigerant if actual temperature is more than 3°F higher than proper suction-tube temperature, or remove refrigerant if actual temperature is more than 3°F lower than required suction-tube temperature.

NOTE: If the problem causing the inaccurate readings is a refrigerant leak, refer to Start-Up, Check for Refrigerant Leaks section.

INDOOR AIRFLOW AND AIRFLOW ADJUSTMENTS

⚠️ CAUTION ⚠️
For cooling operation, the recommended airflow is 350 to 450 cfm per each 12,000 Btu of rated cooling capacity. For heating operation, the airflow must produce a temperature rise that falls within the range stamped on the unit rating plate.

Direct-drive blower motors are factory connected to deliver the proper heating and cooling airflows at normal external static pressures (medium speed cooling, low speed heating for 230-v units) and high speed cooling (units with 460-v have medium speed cooling and high speed heating).

For 208-v operation on 208/230-v rated direct drive units, interchange motor leads to high speed for cooling and medium speed for heating operation.

Table 5 shows the temperature rise at various airflow rates. Tables 8 and 9 show both heating and cooling airflows at various external static pressures. Refer to these tables to determine the airflow for the system being installed.

NOTE: Be sure that all supply- and return-air grilles are open, free from obstructions and adjusted properly.

⚠️ WARNING ⚠️
Disconnect electrical power to the unit before changing blower speed. (Be sure to turn off gas supply before disconnecting electrical power.) Electrical shock can cause personal injury or death.

⚠️ CAUTION ⚠️
Do not change the blower-motor lead connections on 460-v units from the factory setting. Damage to unit may result.
### Table 5 – Air Delivery (Cfm) at Indicated Temperature Rise and Rated Heating Input

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**NOTE:** Dashed areas of the table do not fall in the approved temperature rise range of the unit

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*Superheat at suction service valve.*

**NOTE:** Do not attempt to charge system under these conditions; refrigerant slugging may occur

### Table 7 – Required Suction-Tube Temperature (F)*

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*Temperature at suction service valve.*

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<td>NLT016, NLT024, NHT024, 208/230-1-60</td>
<td>Low†, Med**</td>
<td>Watts</td>
<td>451</td>
</tr>
<tr>
<td>Cfm</td>
<td>1185</td>
<td>1129</td>
<td>1088</td>
</tr>
<tr>
<td>Hi</td>
<td>511</td>
<td>483</td>
<td>464</td>
</tr>
<tr>
<td>NLT030, NMT030 208/230-1-60</td>
<td>Low†, Med**</td>
<td>Watts</td>
<td>519</td>
</tr>
<tr>
<td>Cfm</td>
<td>1184</td>
<td>1163</td>
<td>1150</td>
</tr>
<tr>
<td>Hi</td>
<td>620</td>
<td>602</td>
<td>581</td>
</tr>
<tr>
<td>NHT030, NHT036, NMT036, NMT042, 208/230-1-60, 208/230-3-60, 460-3-60††</td>
<td>Low†, Med**</td>
<td>Watts</td>
<td>560</td>
</tr>
<tr>
<td>Cfm</td>
<td>1515</td>
<td>1452</td>
<td>1389</td>
</tr>
<tr>
<td>Hi</td>
<td>873</td>
<td>847</td>
<td>814</td>
</tr>
<tr>
<td>NET036, 042 208/230-1-60, 208/230-3-60, 460-3-60††</td>
<td>Low†, Med**</td>
<td>Watts</td>
<td>873</td>
</tr>
<tr>
<td>Cfm</td>
<td>1717</td>
<td>1690</td>
<td>1645</td>
</tr>
<tr>
<td>Hi</td>
<td>1075</td>
<td>1030</td>
<td>995</td>
</tr>
<tr>
<td>NHT036, NVT036, NHT042, NVT042 208/230-1-60, 208/230-3-60, 460-3-60††</td>
<td>Low†, Med**</td>
<td>Watts</td>
<td>740</td>
</tr>
<tr>
<td>Cfm</td>
<td>1913</td>
<td>1820</td>
<td>1736</td>
</tr>
<tr>
<td>Hi</td>
<td>790</td>
<td>760</td>
<td>720</td>
</tr>
<tr>
<td>NET048, NMT048 208/230-1-60, 208/230-3-60, 460-3-60††</td>
<td>Low†, Med**</td>
<td>Watts</td>
<td>770</td>
</tr>
<tr>
<td>Cfm</td>
<td>1945</td>
<td>1880</td>
<td>1796</td>
</tr>
<tr>
<td>Hi</td>
<td>850</td>
<td>810</td>
<td>770</td>
</tr>
<tr>
<td>NVT048 208/230-1-60, 208/230-3-60, 460-3-60††</td>
<td>Low†, Med**</td>
<td>Watts</td>
<td>985</td>
</tr>
<tr>
<td>Cfm</td>
<td>1931</td>
<td>1901</td>
<td>1862</td>
</tr>
<tr>
<td>Hi</td>
<td>1220</td>
<td>1165</td>
<td>1130</td>
</tr>
<tr>
<td>NLT060, NMT060, NHT060, 208/230-1-60, 208/230-3-60, 460-3-60††</td>
<td>Low†, Med**</td>
<td>Watts</td>
<td>1125</td>
</tr>
<tr>
<td>Cfm</td>
<td>2184</td>
<td>2125</td>
<td>2063</td>
</tr>
<tr>
<td>Hi</td>
<td>1220</td>
<td>1175</td>
<td>1125</td>
</tr>
<tr>
<td>NVT060 208/230-1-60, 208/230-3-60, 460-3-60††</td>
<td>Watts</td>
<td>2380</td>
<td>2307</td>
</tr>
</tbody>
</table>

*Air delivery values are without air filter and are for dry coil. See Table 10 for wet coil pressure drop. Deduct field-supplied air filter pressure drop and wet coil pressure drop to obtain external static pressure available for ducting.
†Factory blower-motor speed setting for heating operation.
**Factory blower-motor speed setting for cooling operation.
††Do not change blower speed settings for units with 460-v (high speed only).

NOTE: Do not operate the unit at a cooling airflow that is less than 350 cfm per each 12,000 Btu of rated cooling capacity. Evaporator coil icing may occur at airflows below this point. Water blow-off may occur at airflows above 450 cfm per 12,000 Btu of rated cooling capacity.

The heating and/or cooling airflow of 208/230-v direct-drive blower motors can be changed by changing the lead connections of the blower motor. The motor leads are color-coded as follows:
- **black** = high speed
- **blue** = medium speed
- **red** = low speed

NOTE: For all 208/230-v direct-drive units, the red motor lead connected to the heat relay (L) on PC1 blower control determines the heating speed and resulting airflow, and the blue motor lead connected to the cooling relay (H) on PC1 blower control determines the cooling speed and resulting airflow. See the unit wiring label.

To change the heating and/or cooling speed of a direct-drive motor, connect the appropriate color-coded lead at blower motor connector to speed-tap desired. (See unit wiring label.)

When installing a 208- or 230-v direct-drive unit that is factory connected for heating and cooling speeds that are not the same, and the same speed for both heating and cooling is required for a particular application, disconnect red lead at terminal L of heat relay and connect to terminal M1 on PC1 blower control. Connect a field-supplied jumper between terminal L on heat relay and terminal H of cooling relay. Connect blue lead at blower motor to appropriate speed tap.
<table>
<thead>
<tr>
<th>48 V-PH-HZ</th>
<th>MOTOR SPEED</th>
<th>208 V</th>
<th>230 V or 480 V</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>in. wg</td>
<td>0.0</td>
<td>0.1</td>
</tr>
<tr>
<td>NLT018, NLT024</td>
<td>Low†, Med**</td>
<td>Watts</td>
<td>435</td>
</tr>
<tr>
<td>NHT024</td>
<td>Crm</td>
<td>1102</td>
<td>1104</td>
</tr>
<tr>
<td>208/230-1-60</td>
<td>Watts</td>
<td>491</td>
<td>483</td>
</tr>
<tr>
<td>Crm</td>
<td>1308</td>
<td>1234</td>
<td>1162</td>
</tr>
<tr>
<td>NLT030, NMT030</td>
<td>Low†, Med**</td>
<td>Watts</td>
<td>509</td>
</tr>
<tr>
<td>208/230-1-60</td>
<td>Crm</td>
<td>1155</td>
<td>1138</td>
</tr>
<tr>
<td>NMT032, NLT036</td>
<td>High</td>
<td>Watts</td>
<td>600</td>
</tr>
<tr>
<td>NMT042</td>
<td>Crm</td>
<td>1411</td>
<td>1362</td>
</tr>
<tr>
<td>208/230-1-60</td>
<td>Watts</td>
<td>522</td>
<td>504</td>
</tr>
<tr>
<td>208/230-1-60</td>
<td>Crm</td>
<td>1494</td>
<td>1430</td>
</tr>
<tr>
<td>3-60††</td>
<td>High</td>
<td>Watts</td>
<td>651</td>
</tr>
<tr>
<td>Crm</td>
<td>1683</td>
<td>1615</td>
<td>1536</td>
</tr>
<tr>
<td>NET036, NET042</td>
<td>Low†, Med**</td>
<td>Watts</td>
<td>833</td>
</tr>
<tr>
<td>208/230-1-60</td>
<td>Crm</td>
<td>1853</td>
<td>1811</td>
</tr>
<tr>
<td>NHT042, NVT036</td>
<td>High</td>
<td>Watts</td>
<td>945</td>
</tr>
<tr>
<td>NVT042</td>
<td>Crm</td>
<td>1895</td>
<td>1839</td>
</tr>
<tr>
<td>208/230-3-60</td>
<td>Watts</td>
<td>680</td>
<td>645</td>
</tr>
<tr>
<td>460-3-60††</td>
<td>Crm</td>
<td>1797</td>
<td>1709</td>
</tr>
<tr>
<td>NVT048, NHT048</td>
<td>Low†, Med**</td>
<td>Watts</td>
<td>750</td>
</tr>
<tr>
<td>208/230-1-60</td>
<td>Crm</td>
<td>1985</td>
<td>1779</td>
</tr>
<tr>
<td>208/230-3-60</td>
<td>Watts</td>
<td>710</td>
<td>680</td>
</tr>
<tr>
<td>460-3-60††</td>
<td>Crm</td>
<td>1833</td>
<td>1768</td>
</tr>
<tr>
<td>NVT048</td>
<td>High</td>
<td>Watts</td>
<td>785</td>
</tr>
<tr>
<td>NVT060, NHT060</td>
<td>Low†, Med**</td>
<td>Watts</td>
<td>985</td>
</tr>
<tr>
<td>208/230-3-60</td>
<td>Crm</td>
<td>1878</td>
<td>1821</td>
</tr>
<tr>
<td>460-3-60††</td>
<td>Watts</td>
<td>1130</td>
<td>1097</td>
</tr>
<tr>
<td>NLT060, NMT060</td>
<td>High</td>
<td>Watts</td>
<td>2199</td>
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<td>Crm</td>
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</tr>
<tr>
<td>NTV060</td>
<td>Watts</td>
<td>2125</td>
<td>2165</td>
</tr>
</tbody>
</table>

*Air delivery values are without air filter and are for dry coil. See Table 10 for wet coil pressure drop. Deduct field-supplied air filter pressure drop and wet coil pressure drop to obtain external static pressure available for ducting.
†Factory blower-motor speed setting for heating operation.
†Factory blower-motor speed setting for cooling operation.
††Do not change blower speed settings for units with 460-v (high speed only).

NOTE: Do not operate the unit at a cooling airflow that is less than 350 cfm per each 12,000 Btuh of rated cooling capacity. Evaporator coil icing may occur at airflows below this point. Water blow-off may occur at airflows above 450 cfm per 12,000 Btuh of rated cooling capacity.

UNIT CONTROLS — All compressors have the following internal-protection controls:

1. High-Pressure Relief Valve — This valve opens when the pressure differential between the low and high side becomes excessive.
2. Compressor Overload — This overload interrupts power to the compressor when either the current or internal temperature become excessive, and automatically resets when the internal temperature drops to a safe level.

This overload may require up to 60 minutes (or longer) to reset; therefore, if the internal overload is suspected of being open, disconnect the electrical power to the unit and check the circuit through the overload with an ohmmeter or continuity tester.

COOLING SEQUENCE OF OPERATION

NOTE: Although the actual unit wiring may vary slightly from that shown in Fig. 13 and 14, the sequence of operation will not be affected.

With the room thermostat SYSTEM switch in the COOL position and the FAN switch in the ALTO position, the cooling sequence of operation is as follows:

When the room temperature rises to a point that is slightly above the cooling control setting of the thermostat, the thermostat completes the circuit between the thermostat terminal R
to terminals Y and G. These completed circuits through the thermostat connect contactor coil C (through unit wire Y) and relay coil IFR1 (through unit wire G) across the 24-v secondary of transformer TRAN.

The normally open contacts of energized contactor C close and complete the circuit through compressor motor COMP and condenser fan motor OFM. Both motors start instantly.

The set of normally open contacts of energized relay IFR1 close and complete the circuit through evaporator blower motor IFM. The blower motor starts instantly.

NOTE: The cooling cycle remains “on” until the room temperature drops to point that is slightly below the cooling control setting of the room thermostat. At this point, the thermostat “breaks” the circuit between thermostat terminal R to terminals Y and G. These open circuits de-energize contactor coil C and relay coil IFR1. The condenser and compressor motors stop. After a 45-second delay, the blower motor stops. The unit is in a “standby” condition, waiting for the next “call for cooling” from the room thermostat.

<table>
<thead>
<tr>
<th>MODEL</th>
<th>AIRFLOW (cfm)</th>
<th>WET COIL PD (in. wg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>018,024</td>
<td>600</td>
<td>.038</td>
</tr>
<tr>
<td></td>
<td>700</td>
<td>.044</td>
</tr>
<tr>
<td></td>
<td>800</td>
<td>.052</td>
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<td></td>
<td>900</td>
<td>.062</td>
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<tr>
<td>030</td>
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<td>.042</td>
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<td></td>
<td>1200</td>
<td>.064</td>
</tr>
<tr>
<td>036,042</td>
<td>1000</td>
<td>.038</td>
</tr>
<tr>
<td></td>
<td>1200</td>
<td>.050</td>
</tr>
<tr>
<td></td>
<td>1400</td>
<td>.064</td>
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<td>1600</td>
<td>.060</td>
</tr>
<tr>
<td></td>
<td>1800</td>
<td>.072</td>
</tr>
<tr>
<td>060</td>
<td>1700</td>
<td>.100</td>
</tr>
<tr>
<td></td>
<td>1800</td>
<td>.120</td>
</tr>
<tr>
<td></td>
<td>2100</td>
<td>.140</td>
</tr>
<tr>
<td></td>
<td>2300</td>
<td>.160</td>
</tr>
</tbody>
</table>

**MAINTENANCE**

To ensure continuing high performance, and to minimize the possibility of premature equipment failure, periodic maintenance must be performed on this equipment. This combination heating/cooling unit should be inspected at least once each year by a qualified service person. To troubleshoot heating or cooling of units, refer to Tables 11 and 12.

**NOTE TO EQUIPMENT OWNER:** Consult your local Dealer about the availability of a maintenance contract.

**WARNING**

The ability to properly perform maintenance on this equipment requires certain expertise, mechanical skills, tools and equipment. If you do not possess these, do not attempt to perform any maintenance on this equipment, other than those procedures recommended in the User’s Manual. FAILURE TO HEED THIS WARNING COULD RESULT IN SERIOUS PERSONAL INJURY AND POSSIBLE DAMAGE TO THIS EQUIPMENT.

The minimum maintenance requirements for this equipment are as follows:
1. Inspect air filter(s) each month. Clean or replace when necessary.
2. Inspect cooling coil, drain pan and condensate drain each cooling season for cleanliness. Clean when necessary.
3. Inspect blower motor and wheel for cleanliness and check lubrication each heating and cooling season. Clean and lubricate (if required) when necessary.
4. Check electrical connections for tightness and controls for proper operation each heating and cooling season. Service when necessary.
5. Check and inspect heating section before each heating season. Clean and adjust when necessary.
6. Check and clean vent screen if needed.

**WARNING**

Failure to follow these warnings could result in serious personal injury:
1. Turn off gas supply, then turn off electrical power to the unit before performing any maintenance or service on the unit.
2. Use extreme caution when removing panels and parts. As with any mechanical equipment, personal injury can result from sharp edges, etc.
3. Never place anything combustible either on, or in contact with, the unit.
4. Should overheating occur, or the gas supply fail to shut off, shut off the external main manual gas valve to the unit, then shut off the electrical supply.
<table>
<thead>
<tr>
<th>SYMPTOM</th>
<th>CAUSE</th>
<th>REMEDY</th>
</tr>
</thead>
<tbody>
<tr>
<td>IGN locked out.</td>
<td>LED flashing</td>
<td>Look for problems external to the ignitor module.</td>
</tr>
<tr>
<td></td>
<td>LED glowing continuously</td>
<td>Replace IGN control.</td>
</tr>
<tr>
<td>Pilot will not light.</td>
<td>No spark at electrode</td>
<td>Check air gap between electrode tip and pilot target. Gap should be as shown in Fig. 15. Readjust as necessary.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Clean moisture or dirt accumulation on electrode ceramic with cloth.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cracked ceramic — replace pilot electrode assembly.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Check for loose or broken wiring at and between electronic control head and electrode. Replace wire or tighten connection as necessary.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Check fuses or circuit breaker to ensure voltage to unit.</td>
</tr>
<tr>
<td></td>
<td>Spark shorting out to main</td>
<td>Realign electrode tip away from main burner but maintain spark gap to pilot burner. See Fig. 15.</td>
</tr>
<tr>
<td>Burners will not ignite.</td>
<td>Gas in line</td>
<td>Drain — Install water trap.</td>
</tr>
<tr>
<td></td>
<td>No power to furnace</td>
<td>Check power supply, fuses, wiring or circuit breaker.</td>
</tr>
<tr>
<td></td>
<td>24-v power supply to control</td>
<td>Check transformer — replace if necessary.</td>
</tr>
<tr>
<td></td>
<td>circuit</td>
<td>Miwired or loose connections</td>
</tr>
<tr>
<td></td>
<td>Dirty pilot — yellow flame</td>
<td>Clean pilot orifice.</td>
</tr>
<tr>
<td></td>
<td>Pilot burning improperly —</td>
<td>Replace pilot.</td>
</tr>
<tr>
<td>Inadequate heating.</td>
<td>24-v power supply to control</td>
<td>Replace thermostat.</td>
</tr>
<tr>
<td></td>
<td>circuit</td>
<td>1. Check for 24 v between terminals MV and COM on control head. If you read 24 v, replace gas valve portion of control head/gas valve assembly.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. If 24 v is not present, check flame sensor for cracked ceramic insulator or shorted sensor cable.</td>
</tr>
<tr>
<td></td>
<td>Broken thermostat wire</td>
<td>Run continuity check to locate break.</td>
</tr>
<tr>
<td>Poor flame characteristics.</td>
<td>Dirty filter</td>
<td>Clean or replace filter as necessary.</td>
</tr>
<tr>
<td></td>
<td>Gas input to furnace too</td>
<td>Check gas pressure at manifold. Clock gas meter for input. If too low, increase manifold pressure, or replace with correct orifices.</td>
</tr>
<tr>
<td></td>
<td>low</td>
<td>Unit undersized for application</td>
</tr>
<tr>
<td></td>
<td>Restricted airflow</td>
<td>Replace with proper unit — or add additional unit.</td>
</tr>
<tr>
<td></td>
<td>Blower speed too low</td>
<td>Use faster speed tap.</td>
</tr>
<tr>
<td></td>
<td>Limit switch cycles main</td>
<td>Dirty air filters — clean or replace.</td>
</tr>
<tr>
<td></td>
<td>burners</td>
<td>Registers closed, restricted ductwork — open or remove restriction.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Check temperature rise.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Check heat anticipator setting on thermostat — readjust.</td>
</tr>
<tr>
<td></td>
<td>Incomplete combustion results</td>
<td>Check all screws around flue outlets and burner compartment — tighten.</td>
</tr>
<tr>
<td></td>
<td>in:</td>
<td>LACK OF COMBUSTION AIR.</td>
</tr>
<tr>
<td></td>
<td>Aldehyde odors, CO, soothing</td>
<td>Cracked heat exchanger — replace.</td>
</tr>
<tr>
<td></td>
<td>flame — floating flame</td>
<td>Overfired furnace — reduce input, or change orifices.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Check vent for restriction — clean as required</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Check orifice for burner alignment.</td>
</tr>
</tbody>
</table>

GR — Ground  
LP — Liquid Propane
<table>
<thead>
<tr>
<th>Symptom</th>
<th>Cause</th>
<th>Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compressor and condenser fan will not start.</td>
<td>Power failure</td>
<td>Call power company</td>
</tr>
<tr>
<td></td>
<td>Fuse blown or circuit breaker tripped</td>
<td>Replace fuse or reset circuit breaker.</td>
</tr>
<tr>
<td></td>
<td>Defective thermostat, contactor, transformer or control relay</td>
<td>Replace component.</td>
</tr>
<tr>
<td></td>
<td>Insufficient line voltage</td>
<td>Determine cause and correct.</td>
</tr>
<tr>
<td></td>
<td>Incorrect or faulty wiring</td>
<td>Check wiring diagram and rewire correctly.</td>
</tr>
<tr>
<td></td>
<td>Thermostat setting too high</td>
<td>Lower thermostat setting below room temperature</td>
</tr>
<tr>
<td>Compressor will not start but condenser fan runs.</td>
<td>Faulty wiring or loose connections in compressor circuit</td>
<td>Check wiring and repair or replace.</td>
</tr>
<tr>
<td></td>
<td>Compressor motor burned out, seized or internal overload open</td>
<td>Determine cause. Replace compressor.</td>
</tr>
<tr>
<td></td>
<td>Defective run/start capacitor, overload, start relay</td>
<td>Determine cause and replace.</td>
</tr>
<tr>
<td></td>
<td>One leg of 3-phase power dead</td>
<td>Replace fuse or reset circuit breaker.</td>
</tr>
<tr>
<td>Compressor cycles (other than normally satisfying thermostat).</td>
<td>Refrigerant overcharge or undercharge</td>
<td>Blow refrigerant, evacuate system and recharge to nameplate.</td>
</tr>
<tr>
<td></td>
<td>Defective compressor</td>
<td>Replace and determine cause.</td>
</tr>
<tr>
<td></td>
<td>Insufficient line voltage</td>
<td>Determine cause and correct.</td>
</tr>
<tr>
<td></td>
<td>Blocked condenser</td>
<td>Determine cause and correct.</td>
</tr>
<tr>
<td></td>
<td>Defective run/start capacitor, overload or start relay</td>
<td>Determine cause and replace.</td>
</tr>
<tr>
<td></td>
<td>Defective thermostat</td>
<td>Replace thermostat.</td>
</tr>
<tr>
<td></td>
<td>Faulty condenser fan motor or capacitor</td>
<td>Replace.</td>
</tr>
<tr>
<td></td>
<td>Restriction in refrigerant system</td>
<td>Locate restriction and remove.</td>
</tr>
<tr>
<td>Compressor operates continuously.</td>
<td>Dirty air filter</td>
<td>Replace filter.</td>
</tr>
<tr>
<td></td>
<td>Unit undersized for load</td>
<td>Decrease load or increase unit size.</td>
</tr>
<tr>
<td></td>
<td>Thermostat set too low</td>
<td>Reset thermostat.</td>
</tr>
<tr>
<td></td>
<td>Low refrigerant charge</td>
<td>Locate leak, repair and recharge.</td>
</tr>
<tr>
<td></td>
<td>Leaking valves in compressor</td>
<td>Replace compressor.</td>
</tr>
<tr>
<td></td>
<td>Air in system</td>
<td>Blow refrigerant, evacuate system and recharge.</td>
</tr>
<tr>
<td></td>
<td>Condenser coil dirty or restricted</td>
<td>Clean coil or remove restriction.</td>
</tr>
<tr>
<td>Excessive head pressure.</td>
<td>Dirty air filter</td>
<td>Replace filter.</td>
</tr>
<tr>
<td></td>
<td>Dirty condenser coil</td>
<td>Clean coil.</td>
</tr>
<tr>
<td></td>
<td>Refrigerant overcharged</td>
<td>Purge excess refrigerant.</td>
</tr>
<tr>
<td></td>
<td>Air in system</td>
<td>Blow refrigerant, evacuate system and recharge.</td>
</tr>
<tr>
<td></td>
<td>Condenser air restricted or air short-cycling</td>
<td>Determine cause and correct.</td>
</tr>
<tr>
<td>Head pressure too low.</td>
<td>Low refrigerant charge</td>
<td>Check for leaks, repair and recharge.</td>
</tr>
<tr>
<td></td>
<td>Compressor valves leaking</td>
<td>Replace compressor.</td>
</tr>
<tr>
<td></td>
<td>Restriction in liquid tube</td>
<td>Remove restriction.</td>
</tr>
<tr>
<td>Excessive suction pressure.</td>
<td>High heat load</td>
<td>Check for source and eliminate.</td>
</tr>
<tr>
<td></td>
<td>Compressor valves leaking</td>
<td>Replace compressor.</td>
</tr>
<tr>
<td></td>
<td>Refrigerant overcharged</td>
<td>Purge excess refrigerant.</td>
</tr>
<tr>
<td>Suction pressure too low.</td>
<td>Dirty air filter</td>
<td>Replace filter.</td>
</tr>
<tr>
<td></td>
<td>Low refrigerant charge</td>
<td>Check for leaks, repair and recharge.</td>
</tr>
<tr>
<td></td>
<td>Metering device or low side restricted</td>
<td>Remove source of restriction.</td>
</tr>
<tr>
<td></td>
<td>Insufficient evaporator airflow</td>
<td>Increase air quantity. Check filter — replace if necessary</td>
</tr>
<tr>
<td></td>
<td>Temperature too low in conditioned area</td>
<td>Reset thermostat.</td>
</tr>
<tr>
<td></td>
<td>Outdoor ambient below 55 F</td>
<td>Install low-ambient kit.</td>
</tr>
<tr>
<td></td>
<td>Field-installed filter-drier restricted</td>
<td>Replace.</td>
</tr>
</tbody>
</table>
Air Filter

**CAUTION**

Never operate the unit without a suitable air filter in the return-air duct system. Always replace the filter with the same dimensional size and type as originally installed. See Table 1 for recommended filter sizes.

Inspect air filter(s) at least once each month and replace (disposable-type) or clean (cleanable-type) at least twice during each heating and cooling season or whenever the filter(s) becomes clogged with dust and lint.

Replace filters with the same dimensional size and type as originally provided, when necessary.

**Unit Top Removal**

**CAUTION**

Condenser fan and motor are fastened to the unit top. When removing the top, use extreme care to not pull the fan motor leads loose.

NOTE: When performing maintenance or service procedures that require removal of the unit top, be sure to perform all of the routine maintenance procedures that require top removal, including: inspection of the heat exchanger area, coil inspection and cleaning, and condensate drain pan inspection and cleaning.

Only qualified service personnel should perform maintenance and service procedures that require unit top removal. Refer to the following top removal procedures:

1. Turn off gas supply, then turn off electric power to unit.
2. Remove all screws that secure unit top, including screws around 4 sides and those on top that screw into internal divider panels. Save all screws.
3. Tape all side panels at each seam near unit top. Use tape strips that are at least 5-in. long to prevent sides from falling when top is removed.
4. Lift top from unit carefully. Set top on edge and make sure that top is supported by unit side that is opposite duct (or plenum) side. Use extreme care to prevent damage to the fan blades, motor and insulation.
5. Carefully replace and secure unit top to unit, using screws removed in Step 2, when maintenance and/or service procedures are completed. (Be sure to use original screws that have rubber washers to seal out water when securing top to internal divider panels.)

**Evaporator Blower and Motor**

NOTE: Motors without oilers are prelubricated. Do not attempt to lubricate these motors.

For longer life, operating economy and continuing efficiency, clean accumulated dirt and grease from the blower wheel and motor annually.

Lubricate the motor every 5 years if the motor is used intermittently (thermostat FAN switch in AUTO. position), or every 2 years if the motor is used continuously (thermostat FAN switch in ON position).

**WARNING**

Turn off the gas supply, then disconnect and tag electrical power to the unit before cleaning and lubricating the blower motor and wheel. Failure to adhere to this warning could cause personal injury or death.

To clean and lubricate the blower motor and wheel for direct-drive models:

1. Remove and disassemble blower assembly as follows:
   a. Remove blower access door.
   b. Disconnect blower-motor leads from their termination points at motor. Disconnect yellow lead from control box at capacitor. Disconnect auxiliary limit-switch leads at switch.
   c. Remove blower assembly from unit. Be careful not to tear insulation in blower compartment.
   d. Ensure proper reassembly by marking blower wheel and motor in relation to blower housing before disassembly.
   e. Loosen setscrew(s) that secures wheel to motor shaft, remove screws that secure motor mount: brackets to housing and slide motor and motor mount out of housing.
2. Lubricate motor as follows:
   a. Thoroughly clean all accumulations of dirt or grease from motor housing.
   b. Remove dust caps or plugs from oil ports located at each end of motor.
   c. Use a good grade of SAE 20 nondetergent motor oil and put one teaspoon (5 cc, 3/6 oz., or 16 to 25 drops) in each oil port.
   d. Allow time for oil to be absorbed by each bearing, then wipe excess oil from motor housing.
   e. Replace dust caps or plugs in oil ports.
3. Remove and clean blower wheel as follows:
   a. Ensure proper reassembly by marking wheel orientation and cutoff plate location.
   b. Remove screws holding cut-off plate, and remove plate from housing.
   c. Lift wheel from housing. When handling and/or cleaning blower wheel, be sure not to disturb balance weights (clips) on blower wheel vanes.
   d. Remove caked-on dirt from wheel and housing with a brush. Remove lint and/or dirt accumulations from wheel and housing with vacuum cleaner, using soft brush attachment. Remove grease and oil with mild solvent.
   e. Reassemble wheel and cut-off plate into housing.
   f. Reassemble motor into housing. Be sure setscrews are tightened on motor shaft flats and not on round part of shaft.
Heating Section — Ensure dependable and efficient heating operation by inspecting the heating section before each heating season, and cleaning when necessary.

Proceed as follows to inspect and clean heating section:

1. Turn off gas and power to unit.
2. Remove burner access door.
3. Disconnect 2 wires from inducer motor.
4. Remove complete inducer assembly from unit.
5. Remove screws that secure collector box to heat exchanger, exposing flue openings.
6. Remove flue choke.
7. Clean heat exchanger cells using field-provided small wire brush, steel spring cable, reversible electric drill and vacuum cleaner.

To assemble wire brush and steel spring cable:
NOTE: The items below can be purchased at a local hardware store.

a. Use 4 ft of ¼ in. diameter high-grade steel spring cable (commonly known as drain cleanout or Roto-Rooter cable).
b. Use ¼-in. diameter wire brush (commonly known as 25-caliber rifle cleaning brush).
c. Insert twisted wire end of brush into end of spring cable; crimp tight with crimping tool or strike with ball-peen hammer. Tightness is very important.
d. Remove metal sleeve from wire brush to allow proper brush action.

To clean each heat exchanger cell:

a. Attach variable-speed reversible drill to end of spring cable (end opposite brush).
b. Insert brush end of cable into upper opening of cell and slowly rotate with drill. Do not force cable. Gradually insert at least 3 ft of cable into 2 upper passes of cell.
c. Work cable in and out of cell 3 or 4 times to obtain sufficient cleaning. Do not pull cable with great force. Reverse drill and gradually work cable out.
d. Remove burner assembly.
e. Insert brush end of cable in lower opening of cell and proceed to clean in same manner.
f. Repeat above procedures until each cell in unit is cleaned.
g. Using vacuum cleaner, remove residue from each cell.
h. Using vacuum cleaner with soft brush attachment, clean burner assembly.
i. Reinstall burner assembly.
8. After cleaning, check sealant and gaskets to make sure that they have not been damaged. If new sealants or gaskets are needed, contact your Distributor.
9. Reinstall flue choke. Be sure all screws are in and are tight.
10. Clean and replace flue collector assembly, making sure all screws are secure.
11. Replace inducer assembly.
12. Reconnect the 2 wires to inducer motor.
13. Replace burner access door.
14. Turn on power and gas.
15. Set thermostat and check unit for proper operation.

Pilot — Inspect the pilot and clean (when necessary) at the beginning of each heating season. Remove the accumulation of soot and carbon from the pilot. The pilot flame must be high enough for proper contact with the flame sensor. Pilot flame must also come in contact with the pilot hood (target) for proper operation. If the pilot flame appears too hard (lifting and blowing) or too soft (unstable), check inlet gas pressure for proper value. (See Table 4.) The spark electrode must be located so the spark travels through a combustible mixture of gas; if necessary, readjust the electrode as shown in Fig. 15; be certain to maintain the ¼-in. spark gap.

![Fig. 15 — Position of Electrode to Pilot](image)

Condenser Coil, Evaporator Coil and Condensate Drain Pan — Inspect the condenser coil, evaporator coil and condensate drain pan at least once each year. Proper inspection and cleaning requires the removal of the unit top. See Unit Top Removal section.

The coils are easily cleaned when dry; therefore, inspect and clean the coils either before or after each cooling season. Remove all obstructions, including weeds and shrubs, that interfere with the airflow, through the condenser coil. Straighten bent fins with a fin comb. If coated with dirt or lint, clean the coils with a vacuum cleaner, using the soft brush attachment. Be careful not to bend the fins. If coated with oil or grease, clean the coils with a mild detergent-and-water solution. Rinse coils with clear water, using a garden hose. Be careful not to splash water on motors, insulation, wiring or air filter(s). For best results, spray condenser coil fins from inside to outside the unit. On units with an outer and inner condenser coil, be sure to clean between the coils. Be sure to flush all dirt and debris from the unit base.

Inspect the drain pan and condensate drain line when inspecting the coils. Clean the drain pan and condensate drain by removing all foreign matter from the pan. Flush the pan and drain tube with clear water. Do not splash water on the insulation, motor, wiring or air filter(s). If the drain tube is restricted, clear it with a "plumbers snake" or similar probe device.
Condenser Fan

**CAUTION**

Keep the condenser fan free from all obstructions to ensure proper cooling operation. Never place articles on top of the unit. Damage to unit may result.

Remove control and compressor access panels. Inspect the fan blades for cracks or bends each year. Make sure that blades clear the motor by no more than 1/4 inch. If the blade assembly has slipped down the motor shaft, adjust the fan position on the motor shaft by loosening the set-screw(s), then moving the blade assembly up. Be sure that the set-screw(s) is on the flat(s) of the motor shaft before tightening.

**Electrical Controls and Wiring** — Inspect and check the electrical controls and wiring annually. Be sure to turn off the gas supply, and then the electrical power to the unit.

Remove the control, blower and compressor compartment access panels to locate all the electrical controls and wiring. Check all electrical connections for tightness. Tighten all screw connections. If any smoky or burned connections are noticed, disassemble the connection, clean all the parts, restrip the wire end and reassemble the connection properly and securely.

After inspecting the electrical controls and wiring, replace all the panels. Start the unit, and observe at least one complete heating cycle and one complete cooling cycle to ensure proper operation. If discrepancies are observed in either or both operating cycles, or if a suspected malfunction has occurred, check each electrical component with the proper electrical instrumentation. Refer to the unit wiring label when making these checkouts.

**NOTE:** Refer to the heating and/or cooling sequence of operation in this publication as an aid in determining proper control operation.

**Refrigerant Circuit** — Inspect all refrigerant tubing connections and the unit base for oil accumulations annually. Detecting oil generally indicates a refrigerant leak.

If oil is detected or if low cooling performance is suspected, leak-test all refrigerant tubing using an electronic leak-detector, or liquid-soap solution. If a refrigerant leak is detected, refer to Start-Up, Check for Refrigerant Leaks section.

If no refrigerant leaks are found and low cooling performance is suspected, refer to Checking and Adjusting Refrigerant Charge section.

**Gas Input** — The gas input does not require checking unless improper heating performance is suspected. If a problem exists, refer to Start-Up section.

**Evaporator Airflow** — The heating ard/or cooling airflow does not require checking unless improper performance is suspected. If a problem exists, be sure that all supply- and return-air grilles are open and free from obstructions, and that the air filter is clean. When necessary, refer to Indoor Airflow and Airflow Adjustment section to check the system airflow.

**Metering Device Servicing** — See Fig. 16 for metering device components. The piston has a refrigerant metering orifice through it. The retainer forms a sealing surface for liquid line flare connection. To check, clean or replace piston:

1. Shut off power to unit.
2. Remove refrigerant from unit using approved refrigerant removal methods from both high- and low-service port connections.
3. Remove liquid line flare connections from metering device.
4. Note position of arrow on metering device body with respect to unit.
5. Pull retainer out of body. Be careful not to scratch flare sealing surface. If retainer does not pull out easily, carefully use locking pliers to remove retainer. Replace scratched or damaged retainer.
6. Slide piston out by inserting a small, soft wire through metering hole (18-gage thermostat wire). See that metering hole, sealing surface around piston cones and fluted portion of piston are not damaged.
7. Use the chart on the unit access panel to determine proper arrangement and size of piston. See Table 13 for piston sizes.

**Liquid Line Strainer** — The liquid line strainer (to protect metering device) is made of wire mesh and locate in the liquid line on inlet side. Strainer is pressed into th line. Remove strainer by threading a no. 10 sheet-metal screw into strainer and pulling the screw with pliers.

---

**Fig. 16 — Metering Device Components**
<table>
<thead>
<tr>
<th>UNIT 48</th>
<th>PISTON IDENTIFICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>NLT018</td>
<td>59</td>
</tr>
<tr>
<td>NLT024</td>
<td>63</td>
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<tr>
<td>NHT024</td>
<td>63</td>
</tr>
<tr>
<td>NLT030</td>
<td>73</td>
</tr>
<tr>
<td>NMT030</td>
<td>73</td>
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<td>NHT030</td>
<td>73</td>
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<tr>
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<td>101</td>
</tr>
<tr>
<td>NVT060</td>
<td>101</td>
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</tbody>
</table>
EJECTOR MECHANICAL SPECIFICATIONS

UNIT TYPE:
Unit is factory assembled, forced draft, cooling tower with moving parts. Air is induced into and through the tower by a water injection process.

WATER DISTRIBUTION:
Water enters the tower and is distributed uniformly through a hot-dip galvanized steel spray tree comprised of a header with built in, removable strainers, distribution branches with provisions for clean-out, and brass spray nozzles. The entire distribution system is accessible from the front of the unit for inspection and maintenance.

PAN SECTION:
The pan section is constructed of hot-dip galvanized steel, finished inside and out with Zinc Chromated Aluminum. Pan includes a sump with drains and cleanout connections. Section connection is provided with an anti-rotating device and large area, hot-dip galvanized steel strainer screens, easily removed for cleaning.

CASING SECTION:
The casing section is constructed of hot-dip galvanized steel finished inside and out with Zinc Chromated Aluminum. Standard accessories include large diameter, circular access doors, and a brass, flow operated make-up valve complete with large diameter plastic flange. (Note: make-up valve omitted on units for remote make-up applications)

INLET AIR STABILIZER:
Inlet air stabilizers are provided on the intake side of the tower to ensure smooth, eddy free air flow into the unit. They are removable in easily handled sections, for access to the spray distribution systems.

ELIMINATORS:
Eliminators constructed of 14 oz melamine integrated nozzles, are provided on the discharge side of the tower to remove entrained mist from the discharge air stream.

DISCHARGE LOUVERS:
Discharge louvers, constructed of hot-dip galvanized steel finished with Zinc Chromated Aluminum are mounted on the discharge side of the tower to direct a high velocity discharge air stream up and away from the tower.

STRAINER SYSTEM:
A double filtration system is included as an integral part of the tower to remove particulate matter and debris from the circulating water. It consists of:
1. Large area, lift out type, hot-dip galvanized steel strainer screens with perforated openings mounted in the tower basin.
2. A large area, removable, hot-dip galvanized steel cylindrical strainer with perforated openings smaller than the screen holes, strainers mounted in the water inlet header. A blow-down connection is provided at the bottom of the header strainer assembly.

CORROSION PROTECTION SYSTEM:
All steel components of the tower are hot-dip galvanized with cut edges and other exposed surfaces coated with a zinc-rich compound. The assembled tower is given a final coat of Zinc Chromated Aluminum for additional corrosion protection. Accelerated corrosion tests on this finish indicate no signs of corrosion when samples are exposed to a twenty percent salt spray solution at 95 degrees F for 2000 hours.

MODIFICATIONS AND ACCESSORIES
☐ Electric Pan Heater Package, Refer to Dwg. BAC-4129B
☐ Steam Coil in Pan, Refer to Dwg. BAC-4133B
☐ Electric Water Level Control Package in lieu of Standard Make-up Valve: Refer to Dwg. BAC-4150B
☐ Bottom Section Connection for Remote Sump Application: (Make-up Valve Assembly Omitted). Refer to Dwg. BAC-4131B
☐ Bottom Section Connection in lieu of Standard (Make-up Valve and Strainer Included). Refer to Dwg. BAC-4131B

REMARKS:
UNIT FURNISHED WITH ONE SET OF PRESSURE GAUGES AND ONE EXTRA FINAL STRAINER.

CERTIFIED FOR:
LESURE COMPANY - LAFAYETTE, CA
CUSTOMER P.O. 8397
PROJECT:
CONTRA COSTA COLLEGE LITTLE THEATER - SAN PABLO, CA
ARCHITECT/ENGINEER:
DAVID K. LISH - SAN FRANCISCO, CA
CERTIFIED PERFORMANCE:
MODEL J0305 B-89 TO COOL 210 U.S. GPM OF WATER FROM 95 °F
TO 85 °F AT 68 °F ENTERING WET BULB AND 34 PSIG SPRAY PRESSURE.

SUBMITTED FOR:
□ APPROVAL
□ CONSTRUCTION
□ REVISION
□ DESTROY PREVIOUS PRINTS

EJECTOR COOLING TOWER

Baltimore Aircoil

Dwg. No. BAC-4120B

REVISIONS

NO. DATE REMARKS

BAC ORDER NO. 79-0022 M

10-14-75
NOTES:
1. SUPPORTING STEELWORK AND ANCHOR BOLTS TO BE SELECTED AND INSTALLED BY OTHERS.
2. ALL SUPPORTING STEEL MUST BE LEVEL AT THE TOP.
3. BEAMS SHOULD BE SELECTED IN ACCORDANCE WITH ACCEPTED STRUCTURAL PRACTICE. MAXIMUM DEFLECTION OF BEAM UNDER UNIT TO BE $\frac{1}{360}$ OF SPAN, NOT TO EXCEED $\frac{1}{8}$ INCH.
4. THE TOWER MAY BE SUPPORTED ON COLUMNS AT THE ANCHOR BOLT LOCATIONS SHOWN, IF REQUIRED. 6" MINIMUM BEARING SURFACE MUST BE PROVIDED UNDER EACH OF THE CONCENTRATED LOAD POINTS.

ALTERNATE STEEL SUPPORT PLAN
(MUST BE USED WITH EJECTORS EMPLOYING BOTTOM WATER OUTLET CONNECTIONS)

<table>
<thead>
<tr>
<th>UNIT</th>
<th>SHIPPING WEIGHT (POUNDS)</th>
<th>OPERATING WEIGHT (POUNDS)</th>
<th>TOWER DIMENSIONS</th>
<th>WEIGHT LOADING POINTS (POUNDS)</th>
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</thead>
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<tr>
<td></td>
<td>A</td>
<td>B</td>
<td>B₁</td>
<td>C</td>
</tr>
<tr>
<td>J0203</td>
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<td>660</td>
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<td>2' - 2\frac{1}{4}&quot;</td>
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<td>1500</td>
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<td>1800</td>
<td>4450</td>
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</tbody>
</table>
# CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>INTRODUCTION</strong></td>
<td></td>
</tr>
<tr>
<td>Unit Description</td>
<td>3</td>
</tr>
<tr>
<td>Fan Section</td>
<td>3</td>
</tr>
<tr>
<td>Coil Section</td>
<td>3</td>
</tr>
<tr>
<td>Accessories</td>
<td>3</td>
</tr>
<tr>
<td><strong>INITIAL PREPARATION</strong></td>
<td>14-15</td>
</tr>
<tr>
<td>Inspection</td>
<td>14</td>
</tr>
<tr>
<td>Handling Precautions</td>
<td>14</td>
</tr>
<tr>
<td><strong>INSTALLATION</strong></td>
<td>16-35</td>
</tr>
<tr>
<td>Unit Location</td>
<td>16</td>
</tr>
<tr>
<td>Floor Mounting</td>
<td>16</td>
</tr>
<tr>
<td>Base Unit Assembly</td>
<td>16</td>
</tr>
<tr>
<td>Fan Motor and Mounting Base</td>
<td>18</td>
</tr>
<tr>
<td>Drive Package</td>
<td>23</td>
</tr>
<tr>
<td>Accessories</td>
<td>26</td>
</tr>
<tr>
<td>Ceiling Suspension</td>
<td>31</td>
</tr>
<tr>
<td>Outdoor Installation</td>
<td>33</td>
</tr>
<tr>
<td>Piping Connections</td>
<td>33</td>
</tr>
<tr>
<td>Discharge Duct Connections</td>
<td>34</td>
</tr>
<tr>
<td>Final Installation Check List</td>
<td>34</td>
</tr>
<tr>
<td><strong>MAINTENANCE</strong></td>
<td></td>
</tr>
<tr>
<td>Coils</td>
<td>36</td>
</tr>
<tr>
<td>Fan Section</td>
<td>36</td>
</tr>
<tr>
<td>Lubrication</td>
<td>37</td>
</tr>
<tr>
<td>Filters</td>
<td>38</td>
</tr>
</tbody>
</table>
INTRODUCTION

UNIT DESCRIPTION

The 39AC Weathermaker is available in thirteen unit sizes, and is designed for single zone applications. The base unit consists of fan section, coil section, and condensate drain pan (Fig. 1). The unit casing is constructed of galvanized steel sheets, and casing panels are removable for access to the inside. Insulation for the fan section and cooling coil section consists of blankets of Neoprene - coated glass wool applied at the factory. The condensate drain pan is insulated with a waterproof expanded plastic cemented to the pan. The Weathermaker is available in both horizontal and vertical arrangements (Fig. 2, 3 and 4). Both unit arrangements are designed for floor mounting, and for either indoor or outdoor installation. The horizontal arrangement is also designed for ceiling suspension.

Low pressure units have the designation 39AC stamped on the unit name plate. Medium pressure units have the designation 39ACM stamped on the name plate. (Table 1 lists physical data for both low and medium pressure units.) On low pressure units, fan shaft bearing supports are located on the outside of the fan section side panels. On medium pressure units, the bearing support on the drive end of the fan shaft is located on the outside of the fan section side panel. The bearing support on the free end of the fan shaft is located inside the fan section.

An adjustable fan motor base is furnished with the unit, and can be located on either side of the front or top panel of the fan section. Variable pitch motor sheaves and V-belts provide a wide range of fan speeds. A belt guard is furnished with the base unit.

FAN SECTION

The fan section, consisting of fan wheels, fan shaft, and fan shaft bearings, is shipped completely assembled. On units with single fan wheels, the fan shaft is constant diameter solid steel, and the shaft ends are finished for standard ball bearings. On units with two fan wheels, the fan shaft is large diameter heavy gauge tubular steel, and the shaft ends are swaged and finished for standard ball bearings. The fan shaft bearings are self-aligning, and are prelubricated at the factory.

On horizontal arrangements, the fan section is mounted in front of the coil section. On vertical arrangements, the fan section is mounted on top of the coil section. (If a reheat coil is used, it is installed between the fan section and cooling coil.) On both arrangements, the fan section can be rotated to provide horizontal or vertical air discharge (Fig. 2, 3 and 4).

COIL SECTION

Cooling Coil

The cooling coil is positioned vertically on both horizontal and vertical unit arrangements, and slides in or out on tracks in the coil section. Either direct expansion or chilled water cooling coils are available. The cooling coil is installed at the factory, and the coil section is shipped completely assembled.

Reheat Coil

The reheat coil is a removable cartridge type coil that is reversible for right or left-hand piping connections. Supply and return piping connections are located on the same end of the coil. Two types of heating coils are available:

1. Return bend coils for use with steam or hot water
2. Nonfreeze steam coils

NOTE: A reheat coil cannot be installed on 39AC4 thru 6 size short horizontal units (Fig. 2) or on 39AC7 thru 12 size units with a short coil section (Fig. 3). Vertical units require a separate vertical heating coil section for the reheat coil (Fig. 2).

ACCESSORIES

Figures 2, 3, and 4 illustrate the arrangement of accessories on the base unit. The following accessories are available:

Face and Bypass Dampers

The face and bypass damper section allows either a fixed or controlled quantity of air to bypass the cooling coil. For fixed bypass, the damper positions are set for a specific bypass air quantity. For controlled bypass, a damper motor is used to regulate the damper positions. A stop on the damper motor can be set to provide a minimum bypass air quantity.
39AC4 THRU 6 HORIZONTAL ARRANGEMENT

39AC7 THRU 14 HORIZONTAL ARRANGEMENT

1 FILTER SECTION
2 COOLING COIL SECTION
3 PLENUM
4 HEATING COIL SECTION
5 FAN WHEEL
6 FAN SECTION
7 MOTOR MOUNTING BASE
8 CONDENSATE DRAIN PAN
9 MIXING BOX

39AC7 THRU 14 VERTICAL ARRANGEMENT

Fig. 1. - Typical 39AC Central Station Weathermakers.
Dimensions are approximate. Current dimension drawings are available on request.

Fig. 2 - 39AC4 Thru 6 Dimensional Data
39AC INSTALLATION

39AC4, 5, 6 SHORT HORIZONTAL

SIDE VIEW

39AC4, 5, 6 HORIZONTAL

FRONT VIEW

39AC4, 5, 6 SHORT HORIZONTAL AND HORIZONTAL

|     | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V |
|     |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
|     | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10| 11| 12| 13| 14| 15| 16| 17| 18| 19| 20| 21| 22| 23| 24| 25| 26|

Connections (In.)

Dimensions are approximate. Current dimension drawings available on request.

Fig. 2 - 39AC4 Thru 6 Dimensional Data (Cont)
39AC4, 5, 6 ACCESSORIES

VERTICAL HEATING
COIL SECTION

NOTE:
THE WIDTH OF ALL
COMPONENTS IS THE SAME
AS THAT OF THE BASE
UNIT UNLESS OTHERWISE
STATED.

INLET WIDTH IS BASE
UNIT WIDTH MINUS 2 1/2

RETURN AIR

OUTDOOR AIR

FLOOR LEVEL

MIXING BOX
(ROTATE ASSEMBLY 180°
TO OBTAIN BOTTOM
AIR INLET)

ACCESS PANEL

FILTER SECTION
(BOTH LOW AND
HIGH VELOCITY)

BYPASS PLENUM SECTION

FACE AND BYPASS DAMPER SECTION

PREHEAT COIL SECTION

LONG BYPASS PLENUM SECTION

39AC4, 5, 6 ACCESSORIES

<table>
<thead>
<tr>
<th>UNIT SIZE</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>J</th>
<th>K</th>
<th>L</th>
<th>M</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Ft</td>
<td>In</td>
<td>Ft</td>
<td>In</td>
<td>Ft</td>
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<td>Ft</td>
<td>In</td>
<td>Ft</td>
<td>In</td>
<td>Ft</td>
<td>In</td>
</tr>
<tr>
<td>5</td>
<td>2</td>
<td>5-3/8</td>
<td>2</td>
<td>0-3/4</td>
<td>1</td>
<td>2-5/8</td>
<td>1</td>
<td>9</td>
<td>7</td>
<td>2-7-1/2</td>
<td>10-1/2</td>
<td>2</td>
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<tr>
<td>6</td>
<td>3</td>
<td>1-3/8</td>
<td>?</td>
<td>6-3/4</td>
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<td>3</td>
<td>9</td>
<td>3-4-1/2</td>
<td>1</td>
<td>1-1/2</td>
</tr>
</tbody>
</table>

Dimensions are approximate. Current dimension drawings are available on request.

Fig. 2 - 39AC4 Thru 6 Dimensional Data (Contd)
39AC7 THRU 12 VERTICAL

INDOOR UNIT VIEW

UNIT SIZE | A | B | C | D | E | F | G | H | J | K & L | MFN | P | R | S | T
---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---
39AC7 | 7 | 2-2 | 5-4 | 4-72 | 2-5 | 1-9 | 5-25 | 3 | 9 | 92 | 5-1 | x | 11 | 3 | 1-5 | 6-8 | 182 TO 154U
39AC8 | 9 | 2-10 | 5-4 | 6-0 | 5-12 | 2-2 | 1-12 | 5-25 | 3 | 9 | 92 | 5-1 | x | 11 | 3 | 1-7 | 6-4 | 182 TO 186U
39AC9 | 2 | 10 | 7-0 | 6-2 | 5-12 | 2-2 | 1-12 | 5-1 | x | 7 | 6-9 | x | 2-7 | 1-11 | x | 4 | 3 | 1-4 | 6-2 | 182 TO 186U
39AC10 | 10 | 3-4 | 7-9 | 6-11 | 5-74 | 2-11 | 7 | 7-0 | 1-0 | 1-0 | 7-6 | x | 3 | 0-6 | 2-3 | x | 4-1 | 3 | 2-0 | 6-11 | 182 TO 186U
39AC11 | 3-4 | 3-6 | 10-0 | 6-14 | 3-2 | 1-11 | 9-0 | 0-6 | 3 | 7 | 6-1 | 4 | 6-9 | x | 3-1 | 2-10 | x | 1-12 | 6 | 1-4 | 11-2 | 182 TO 186U
39AC12 | 4-3 | 10-0 | 8-9 | 4-16 | 3-10 | 9-0 | 0-6 | 3 | 7 | 6 | 1-8 | 9-0 | x | 4-1 | 2-2 | x | 4-2 | 3 | 2-0 | 6-11 | 182 TO 186U

39AC7 THRU 12 ACCESSORIES (VERTICAL)

PREHEAT COIL
HIGH VELOCITY FILTER
LOW VELOCITY FILTER

COMBINATION MIXING BOX AND FILTER ASSEMBLY

PLAEM
FACE & BUMPERS
SPRAY HUMIDIFIER

COOLING COIL SECTION

FIN SECTION

REHEAT COIL
39AC7-9 = 6'
39AC10-12 = 8'

Dimensions are approximate. Current dimension drawings are available on request.

Fig. 3 - 39AC7 Thru 12 Dimensional Data
39AC7 THRU 12 HORIZONTAL (SHORT COIL SECTION SHOWN)

<table>
<thead>
<tr>
<th>UNIT SIZE</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>J</th>
<th>K</th>
<th>L</th>
<th>M</th>
<th>N</th>
<th>X</th>
<th>R</th>
<th>S</th>
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</thead>
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<tr>
<td>39AC7</td>
<td>3-6&quot;</td>
<td>5-6&quot;</td>
<td>5-6&quot;</td>
<td>5-8&quot;</td>
<td>5-8&quot;</td>
<td>3&quot;</td>
<td>3&quot;</td>
<td>3-8&quot;</td>
<td>1-5/8&quot;</td>
<td>4-1/2&quot;</td>
<td>1-5/8&quot;</td>
<td>5/8&quot;</td>
<td>12&quot;</td>
<td>182&quot;</td>
<td>215&quot;</td>
<td></td>
</tr>
<tr>
<td>39AC8</td>
<td>4-5/8&quot;</td>
<td>5-6&quot;</td>
<td>5-8&quot;</td>
<td>5-10&quot;</td>
<td>5-10&quot;</td>
<td>5&quot;</td>
<td>5&quot;</td>
<td>5&quot;</td>
<td>5/8&quot;</td>
<td>2-7/8&quot;</td>
<td>1-3/4&quot;</td>
<td>5/8&quot;</td>
<td>12&quot;</td>
<td>182&quot;</td>
<td>215&quot;</td>
<td></td>
</tr>
<tr>
<td>39AC9</td>
<td>4-1/4&quot;</td>
<td>5-6&quot;</td>
<td>5-8&quot;</td>
<td>5-10&quot;</td>
<td>5-10&quot;</td>
<td>8&quot;</td>
<td>8&quot;</td>
<td>8&quot;</td>
<td>8&quot;</td>
<td>1-3/8&quot;</td>
<td>1-7/8&quot;</td>
<td>8&quot;</td>
<td>12&quot;</td>
<td>182&quot;</td>
<td>215&quot;</td>
<td></td>
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<tr>
<td>39AC10</td>
<td>4-5/8&quot;</td>
<td>6-3/4&quot;</td>
<td>7-1/4&quot;</td>
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<td>7/8&quot;</td>
<td>12&quot;</td>
<td>182&quot;</td>
<td>215&quot;</td>
<td></td>
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<td>39AC10S,11</td>
<td>4-5/8&quot;</td>
<td>6-3/4&quot;</td>
<td>7-1/4&quot;</td>
<td>6-7/8&quot;</td>
<td>6-7/8&quot;</td>
<td>4&quot;</td>
<td>4&quot;</td>
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<td>1-1/2&quot;</td>
<td>7/8&quot;</td>
<td>12&quot;</td>
<td>182&quot;</td>
<td>215&quot;</td>
<td></td>
</tr>
<tr>
<td>39AC12</td>
<td>5-7/8&quot;</td>
<td>10-7/8&quot;</td>
<td>11-1/4&quot;</td>
<td>8-1/4&quot;</td>
<td>8-1/4&quot;</td>
<td>5&quot;</td>
<td>5&quot;</td>
<td>5&quot;</td>
<td>1-1/4&quot;</td>
<td>3-1/2&quot;</td>
<td>1-1/4&quot;</td>
<td>7/8&quot;</td>
<td>12&quot;</td>
<td>182&quot;</td>
<td>215&quot;</td>
<td></td>
</tr>
</tbody>
</table>

39AC7 THRU 12 ACCESSORIES (HORIZONTAL)

Dimensions are approximate. Current dimension drawings are available on request.

Fig. 3 - 39AC7 Thru 12 Dimensional Data (Contd)
39AC INSTALLATION

39AC13, 13.5, 14 VERTICAL

UNIT SIZE

<table>
<thead>
<tr>
<th>UNIT</th>
<th>A</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>J</th>
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<th>L</th>
<th>M</th>
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<tbody>
<tr>
<td>39AC13</td>
<td>5'-0&quot;</td>
<td>9'-0&quot;</td>
<td>5'-0&quot;</td>
<td>4'-6&quot;</td>
<td>2'</td>
<td>3'-0&quot;</td>
<td>2'-0&quot;</td>
<td>9'-4&quot;x4'-6&quot;</td>
<td>3'-4&quot;</td>
<td>3'-4&quot;</td>
<td>3'-4&quot;</td>
<td>182 TO 365U</td>
<td></td>
</tr>
<tr>
<td>39AC13,14</td>
<td>6'-0&quot;</td>
<td>11'-6&quot;</td>
<td>6'-0&quot;</td>
<td>5'-4&quot;</td>
<td>2&quot;</td>
<td>3'-4&quot;</td>
<td>1'-4&quot;</td>
<td>9'-4&quot;x5'-4&quot;</td>
<td>3'-4&quot;</td>
<td>3'-4&quot;</td>
<td>3'-4&quot;</td>
<td>182 TO 365U</td>
<td></td>
</tr>
</tbody>
</table>

39AC13, 13.5, 14 ACCESSORIES (VERTICAL)

BYPASS HEATING COIL
39AC13 = 1'-2 1/2"
39AC13,14 = 1'-6 1/2"

BYPASS DUCT EXTENSION

COMBINATION MIXING BOX AND FILTER ASSEMBLY

LOW VELOCITY FILTER

PREHEAT COIL

PLENUM

FACE & BYPASS DAMPERS

SPRAY HUMIDIFIER

COOLING COIL SECTION

BYPASS DUCT EXTENSION

Dimensions are approximate. Current dimension drawings are available on request.

Fig. 4 - 39AC13 Thru 14 Dimensional Data
Dimensions are approximate. Current dimension drawings are available on request.

Fig. 4 - 39AC13 Thru 14 Dimensional Data (Contd)
### Table 1 - Physical Data - Low and Medium Pressure Units

<table>
<thead>
<tr>
<th>UNIT SIZE</th>
<th>4</th>
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<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Fan Wheels and Number of Outlets</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Number of Blades per Wheel</td>
<td>Low Press. Med.Press.</td>
<td>43</td>
<td>48</td>
<td>51</td>
<td>48</td>
<td>51</td>
<td>51</td>
<td>48</td>
<td>48</td>
<td>48</td>
<td>66</td>
</tr>
<tr>
<td>Shaft Critical Speed (rpm)</td>
<td>Low Press. Med.Press.</td>
<td>2,700</td>
<td>2,550</td>
<td>2,760</td>
<td>3,200</td>
<td>3,400</td>
<td>2,100</td>
<td>2,100</td>
<td>2,100</td>
<td>1,740</td>
<td>980</td>
</tr>
<tr>
<td>Maximum Operating Speed (rpm)</td>
<td>Low Press. Med.Press.</td>
<td>2,160</td>
<td>2,040</td>
<td>2,010</td>
<td>1,695</td>
<td>1,430</td>
<td>1,615</td>
<td>1,165</td>
<td>1,600</td>
<td>1,160</td>
<td>1,390</td>
</tr>
<tr>
<td>Maximum Motor Rated Hp</td>
<td>Low Press. Med.Press.</td>
<td>1-1/2</td>
<td>2</td>
<td>3</td>
<td>7-1/2</td>
<td>10</td>
<td>15</td>
<td>20</td>
<td>25</td>
<td>40</td>
<td>50</td>
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<tr>
<td>Total Outlet Duct Area (sq ft)</td>
<td></td>
<td>.77</td>
<td>1.04</td>
<td>1.78</td>
<td>2.15</td>
<td>3.88</td>
<td>5.25</td>
<td>7.0</td>
<td>9.35</td>
<td>11.9</td>
<td>15.7</td>
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<td>Refrigerating Charge (lb)</td>
<td>4-row</td>
<td>2</td>
<td>4</td>
<td>6</td>
<td>10</td>
<td>13</td>
<td>17</td>
<td>23</td>
<td>31</td>
<td>40</td>
<td>52</td>
</tr>
<tr>
<td></td>
<td>6-row</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>14</td>
<td>19</td>
<td>25</td>
<td>35</td>
<td>46</td>
<td>60</td>
<td>78</td>
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<td>8-row</td>
<td>5</td>
<td>7</td>
<td>9</td>
<td>20</td>
<td>26</td>
<td>34</td>
<td>46</td>
<td>62</td>
<td>80</td>
<td>104</td>
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<tr>
<td>Water Volume (gal.)</td>
<td>4-row</td>
<td>1.1</td>
<td>1.5</td>
<td>2.0</td>
<td>4.1</td>
<td>5.7</td>
<td>7.6</td>
<td>10.0</td>
<td>11.2</td>
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<td>3.0</td>
<td>3.8</td>
<td>7.2</td>
<td>10.6</td>
<td>14.7</td>
<td>19.5</td>
<td>21.8</td>
<td>25.8</td>
<td>34.1</td>
</tr>
<tr>
<td>Filter Boxes (sq ft)</td>
<td>Low Press. Med.Press.</td>
<td>3.6</td>
<td>4.4</td>
<td>7.0</td>
<td>16.7</td>
<td>25.0</td>
<td>33.4</td>
<td>48.4</td>
<td>48.4</td>
<td>80.6</td>
<td>100</td>
</tr>
<tr>
<td>Low Velocity No. and Size (in. thick)</td>
<td>2-16</td>
<td>2-20</td>
<td>2-25</td>
<td>6-20</td>
<td>9-20</td>
<td>12-20</td>
<td>12-20</td>
<td>6-20</td>
<td>10-20</td>
<td>15-20</td>
<td>20-20</td>
</tr>
<tr>
<td>Area (sq ft)</td>
<td>15</td>
<td>17</td>
<td>22</td>
<td>22</td>
<td>31</td>
<td>32</td>
<td>36</td>
<td>66</td>
<td>63</td>
<td>65</td>
<td>65</td>
</tr>
<tr>
<td>High Velocity No. and Size (in. thick)</td>
<td>1-16</td>
<td>1-20</td>
<td>2-25</td>
<td>3-25</td>
<td>5-16</td>
<td>6-16</td>
<td>6-16</td>
<td>6-16</td>
<td>10-20</td>
<td>14-20</td>
<td>14-20</td>
</tr>
<tr>
<td>Area (sq ft)</td>
<td>22</td>
<td>3.5</td>
<td>5.6</td>
<td>10.4</td>
<td>13.3</td>
<td>17.7</td>
<td>22.2</td>
<td>31</td>
<td>32</td>
<td>36</td>
<td>66</td>
</tr>
<tr>
<td>Approximate Operating Weight (lb)</td>
<td>Low Press. Med.Press.</td>
<td>400</td>
<td>470</td>
<td>710</td>
<td>1,260</td>
<td>1,620</td>
<td>2,110</td>
<td>2,610</td>
<td>3,980</td>
<td>3,320</td>
<td>4,800</td>
</tr>
</tbody>
</table>

**NOTES:**

a. Units 39AC12, 13, 13.5 and 14 have sectional blade wheels with each half of the wheel offset.
b. All motors greater than 50 hp must be floor mounted. Center-to-center distance between fan shaft and motor shaft must be determined at job site.
c. The 39AC10.5 unit has one Number 13 size coil.
d. The 39AC13 unit has two Number 13 size coils (total unit capacity split equally between these coils).
e. The 39AC13.5 unit has one Number 11 size coil and one Number 13 size coil (total unit capacity split 54/46 respectively between these coils).
f. The 39AC14 unit has one Number 12 size coil and one Number 13 size coil (total unit capacity split 60/40 respectively between these coils).
g. Maximum working pressure and temperature for heating coils is 200 psig and 400°F. Maximum working pressure and temperature for cooling coils is 300 psig and 200°F. For smaller/12-ton cooling units, maximum working pressure is 150 psig. Avoid fluid or temperature above 180°F to prevent bearings and unit insulation.
h. At maximum capacity, cooling coil and heating coil velocities are well within limits specified in ASHRAE Standard 34-54, entitled "Methods of Testing and Rating Forced-Circulation Air Cooling and Air Heating Coils."  j. For Refrigerant 22 operating charge, multiply by 0.9.  k. On 39AC units, the filter section is used for both high and low filter velocities. If low velocity filters are used, blank-off baffles are removed. On 39AC3.5 units, the low velocity section is used for high velocity filters. Blank-off baffles are added to fill excess area in filter tracks.  l. These weights are for horizontal units, and include fan section, standard coil section with 6 row, 14 ft per inch chilled water coil and 2 row 14 ft per inch hot water coil, weight of water in both coils, low velocity filter section with filters, maximum size motor, belt guard and fan drive. Weights for vertical units are approximately the same.  m. Approximate operating weights for these sizes are based on 50 hp motor.
Plenum

The plenum section is required if accessories are to be installed on the air-entering end of the face and bypass dampers. The plenum is installed between the accessories and the damper section to allow air to pass into the bypass dampers.

Bypass Duct and Duct Extensions

Bypass ductwork is used with the face and bypass dampers to conduct the bypass air. On horizontal units, ductwork is required to bypass the cooling coil and any accessories installed between the damper section and the coil section. On 39AC4 thru 6 size horizontal units, the ductwork can also be used to bypass the reheat coil. On vertical units, ductwork is required to bypass any accessories installed between the damper section and the coil section.

For 39AC4 thru 6 size units, bypass ducts are available in three lengths (short, medium, and long) for use in a variety of bypass arrangements (Fig. 2). For 39AC7 thru 14 size units, a standard size duct is available for bypassing the cooling coil on horizontal units. Duct extensions the same width as the accessory sections, are available for bypassing any accessories installed between damper section and coil section on either horizontal or vertical units.

Long Bypass Plenum

The long bypass plenum is used to bypass the reheat coil on 39AC4 thru 6 size vertical units. This plenum is installed between the face and bypass dampers and the cooling coil section. The upper portion of the plenum conducts bypass air past the reheat coil and into the fan section (Fig. 2). The lower portion of the plenum conducts air from the face dampers into the cooling coil.

Bypass Heating Coil Section

The bypass heating coil section is used as a reheat coil on 39AC7 thru 14 size vertical units with face and bypass dampers. This section is installed between the cooling coil section and the fan section, and provides the required inlet for bypass air. This section can be installed so that bypass air passes thru the reheat coil, or bypasses both the cooling coil and reheat coil.

Mixing Box and Filter Assembly

The mixing box and filter assembly mixes and filters outside and recirculated air. The outside and return air dampers are interconnected to operate simultaneously, and the operating bar connecting the two damper assemblies allows mixing of varying proportions of outside and return air. The linkage for the outside air dampers can be modified at the installation site to provide a maximum and minimum outside air quantity.

For 39AC4 thru 6 size units, the mixing box and filter assembly is formed by combining the separate mixing box with an accessory filter section (see "Filter Section," below). For 39AC7 thru 14 size units, a combination mixing box and filter assembly is available.

Filter Section

The filter section is constructed of heavy gauge galvanized steel. The filters rest on tracks in the filter section, and can be removed from either end. Two filter sections are available:

1. A low velocity filter section with disposable filters for all 39AC units.

2. A high velocity filter section with cleanable filters for 39AC4 thru 12 size units.

NOTE: High velocity filters can be used on 39AC13 thru 14 size units by installing them in the low velocity filter section and blanking off the excess area.

Filter Section Blank-Off Baffles

The filter section blank-off baffles are used to blank off the area remaining when the smaller high velocity filters are used in the low velocity filter section or combination mixing box and filter assembly. The baffles prevent unfiltered air from entering the unit.

Auxiliary Heating Coil Section

The auxiliary heating coil section can be used as a reheat coil section on vertical units, or as a preheat coil section on either vertical or horizontal units.
Humidifiers

The following types of humidifiers are available for use with the base unit:

Spray Humidifier

The spray humidifier is available for 39AC7 thru 14 size units, and consists of a humidifier section with a header and spray nozzles that operate at water pressures of 15 psi or above. A drain connection is provided for draining the humidifier section when disassembly or freeze protection is required. This humidifier can be used on units with copper or aluminum finned coils if soft water is available. If the spray water is hard, or if industrial gases such as hydrogen sulphides, sulphur dioxide, or carbon dioxide are present in the spray water or outside air, the spray humidifier should only be used on units with all-copper coils. If the coils have dissimilar fin and tube materials, hard water and industrial gases can reduce coil life due to corrosion.

Atomizing Spray Humidifier

The atomizing spray humidifier is available for all 39AC units, and consists of several 1/8 inch brass nozzles screwed into a single horizontal pipe placed parallel to the cooling coil. Each nozzle has a spray angle of seventy degrees, and is equipped with a fine mesh strainer made of brass.

Steam Grid Humidifier

The steam grid humidifier is available for all 39AC units, and consists of a steam pipe wrapped in asbestos-impregnated cloth, and passed thru an open or slotted copper pan. The pan is pitched to facilitate condensate drainage. The steam supply to the humidifier must be odor-free to prevent contamination of the air.

Suspension Package

A suspension clip package is available for ceiling suspension of 39AC4 thru 12 size horizontal units. The suspension package contains four suspension clips for 39AC4 thru 6 size units, and six clips for 39AC7 thru 12 size units. The 39AC13 thru 14 size horizontal units must be suspended on a platform.

INITIAL PREPARATION

INSPECTION

Check the packing list to make certain shipment is complete. If any item is missing, notify Carrier at once.

The 39AC4 thru 6 size units are shipped on one skid, completely assembled in either the horizontal or vertical arrangement. Accessories, with the exception of the mixing box, are included on this skid. If the mixing box is ordered, it will be shipped on a separate skid. The various unit arrangements available are identified in Fig. 5.

The 39AC7 thru 14 size units and accessories are shipped on skids, either completely assembled or in sections. All fasteners required for assembly are shipped with major components.

Remove shipping skids and examine unit for damage incurred during shipment. If the unit has been damaged, file claim with the transportation company at once.

CARRIER WILL NOT BE RESPONSIBLE FOR ANY DAMAGE INCURRED IN TRANSIT.

HANDLING PRECAUTIONS

1. Do not remove protective caps from coil piping connections until ready to connect piping.

2. Do not bend or mutilate coil fins.

3. Do not remove protective tape or grease from fan shaft until ready to install fan sheave.

4. Do not lift fan section by fan shaft extension when moving fan section into place.

5. Do not remove fan drives from boxes until ready to install, since boxes are labeled with drive package numbers.

6. When rigging unit, use a spanner bar to avoid bending unit lifting flanges.
HORIZONTAL ARRANGEMENTS WITH RE-HEAT COIL SECTION

HORIZONTAL ARRANGEMENTS WITHOUT RE-HEAT COIL SECTION

VERTICAL ARRANGEMENTS WITH RE-HEAT COIL SECTION

VERTICAL ARRANGEMENTS WITHOUT RE-HEAT COIL SECTION

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**LEGEND**

1. COOLING COIL SECTION
2. PLENUM SECTION
3. HORIZONTAL UNIT HEATING COIL SECTION
4. FAN SELECTION
5. BASE PAN
6. SUSPENSION FRAME AND CLIPS
7. **FILTER SECTION**
8. MIXING BOX
9. AUXILIARY HEATING COIL SECTION
10. BYPASS DAMPER
11. BYPASS DUCT
12. BYPASS PLENUM
13. LONG BYPASS PLENUM
14. VERTICAL UNIT HEATING COIL SECTION

* 39AC-309 MIXING BOX IS NOT INCLUDED OR SHIPPED WITH BASIC UNIT. MUST BE ORDERED AS AN ACCESSORY
** THE FILTER SECTION CAN BE USED WITH EITHER HIGH OR LOW VELOCITY FILTERS

Fig. 5 - 39AC4,5,6 Unit Arrangement and Number
INSTALLATION

UNIT LOCATION

Select installation site to meet job requirements, and take the following precautions when positioning the unit:

1. Allow clearance of at least thirty inches between unit and any wall to provide access to filters and fan motor.

2. Allow sufficient clearance on one side of unit to permit removal of coils and fan shaft.

3. Allow sufficient clearance above unit to permit servicing of dampers, damper linkage, and damper motors.

4. Allow sufficient clearance for unit piping connections so that piping will not prevent removal of fan belt guard.

FLOOR MOUNTING

The unit can be mounted either on rubber-in-shear or spring vibration isolators (not factory furnished), or without vibration isolation, depending on job requirements. For correct positioning of vibration isolators, refer to the installation instructions provided by isolator manufacturer.

On 39AC4 thru 6 size units, both the horizontal and vertical base units set on two support angles welded to the sides of the drain pan perpendicular to the fan shaft. Since the bottoms of the accessory sections are not flush with the bottom of the base unit, a support angle is provided under the factory-installed accessories for shipping purposes. This angle contains 11/16 inch mounting holes, and can be used to support the accessories on floor-mounted units. If a mixing box is to be used, relocate this support angle under the outside flange of the mixing box. If the unit is to be supported on vibration isolators, four isolators are required for the base unit, and two isolators are required for the accessory sections. Install an isolator at each corner of the drain pan, and at each end of the accessory support angle.

On 39AC7 thru 14 size horizontal units, the standard coil section sets on two support channels attached to the bottom of the drain pan under the cooling coil section. Four captive 5/8 inch nuts in the channels provide threaded mounting holes for the coil section. The fan section sets on two support channels that extend the width of the fan section perpendicular to the fan shaft. These support channels contain 11/16 inch mounting holes for the fan section. If the unit is to be supported on vibration isolators, four isolators are required for the coil section, and two isolators are required for the fan section. Install an isolator at each corner of the drain pan, and at each outside corner of the fan section.

On the 39AC7 thru 12 size horizontal units with a short coil section, and 39AC7 thru 14 size vertical units, the base unit sets on two support channels that extend the width of the base unit parallel to the fan shaft. Four captive 5/8 inch nuts in the channels provide threaded mounting holes for the base unit. If the unit is to be supported on vibration isolators, four isolators are required for the base unit, install an isolator at each corner of the base unit.

If a combination mixing box and filter assembly is to be used, it should be supported on separate vibration isolators. Since the bottom of this section is not flush with the bottom of the base unit, a spacer (not factory furnished) is required to support this assembly on the isolators (see "Combination Mixing Box and Filter Assembly," page 31).

BASE UNIT ASSEMBLY

39AC4 Thru 6 Size Units

For 39AC4 thru 6 size units, the fan and coil sections and accessories, with the exception of the mixing box, are normally shipped assembled on one skid. If it is necessary to disconnect these sections when rigging the unit into position, remove the bolts connecting the external flanges. After the unit is in position, reconnect the sections. Level the unit to insure proper drainage from the heating coil and drain pan.

39AC7 Thru 14 Size Units

The fan and coil sections of 39AC7 thru 11 size units are normally shipped assembled on one skid. The 39AC12 thru 14 size fan section and coil section are normally shipped on separate skids. If fan and coil sections are shipped separately, or if it is necessary to disconnect
these sections when rigging the unit into position, assemble as follows:

**Horizontal Arrangement**

1. Set coil section in its proper location.
   
   **NOTE:** If unit is to be ceiling suspended, assemble unit completely before hoisting it into position.

2. Position fan section on air-leaving end of coil section.
   
   **NOTE:** The fan section can be arranged for a variety of air discharge positions.

3. Align bolt holes, and bolt fan and coil sections together using fasteners provided. On 39AC7 thru 12 size units, the side flanges are external, and the top and bottom flanges are internal. On 39AC13 thru 14 size units, all flanges are internal. Remove fan section side panel for access to internal flanges.

   **CAUTION:** Before entering the fan section to bolt the internal flanges together, prevent damage to fan section insulation by placing cardboard or boards on bottom of fan section to serve as a walkway.

4. Level unit to insure proper drainage from heating coil and drain pan.

**Vertical Arrangement**

1. Set cooling coil section in its proper location.

2. If a reheat coil is to be used, position the accessory heating coil section on top of the cooling coil section, and bolt the two sections together.

3. Lift the fan section into position on top of the coil section.

   **NOTE:** The fan section can be arranged for a variety of air discharge positions.

4. Align bolt holes, and bolt fan and coil sections together using fasteners provided. On 39AC7 thru 12 size units, the side flanges are external, and the end flanges are internal. On 39AC13 thru 14 size units, all flanges are internal. Remove coil section side panel for access to internal flanges.

5. On 39AC13 thru 14 size units, install cover piece on top of cooling coil section to fill the space left by the difference in sizes of the fan and coil sections (Fig. 6).

6. Level unit to insure proper drainage from heating coil and drain pan.

**Fig. 6 - Location of Cover Piece on 39AC13 Thru 14 Size Vertical Units**

**Cooling Coil Installation**

The cooling coil is normally shipped installed in the coil section. If the coil is shipped separately, install as follows:

1. Remove both cooling coil cover plates.

2. Remove air baffles from each end of coil track (Fig. 7).

3. Slide cooling coil into position.

4. Install air baffles over coil flanges to prevent air from bypassing the coil.

5. Align bolt holes in coil assembly with bolt holes in coil track, and secure the coil to the coil track.

6. Replace coil cover plates.

**Reheat Coil Installation - Horizontal Units**

The reheat coil, if ordered, is normally shipped installed in the coil section on horizontal units. If the coil is shipped separately, install in the same manner as the cooling coil.
FAN MOTOR AND MOUNTING BASE

39AC4 Thru 6 Size Units

On 39AC4 thru 6 size units, the motor mounting base can be located on either side of the front or top panel of the fan section. The side sections of these panels are interchangeable, and the motor base is shipped installed on one of these sections in the position specified on the sales order. If it is necessary to relocate the motor base, the section on which the base is installed can be interchanged with one of the three other side sections. The belt guard is interchangeable for all standard motor mounting positions.

Install motor and adjust motor base as follows:

1. Set motor mounting bracket to correct height according to motor size. The mounting bracket can be attached at either the inner or outer position on the panel bracket, and can be pivoted to obtain maximum or minimum height at either position (Fig. 8).

2. Bolt motor to motor adjusting bracket (Fig. 8).

3. Bolt motor to motor mounting bracket (Fig. 8).

4. Insert the two adjusting screws as shown in Fig. 8.

39AC7 Thru 14 Size Units

Table 2 lists motor mounting bases available for 39AC7 thru 14 size units. The motor base is shipped strapped to the base unit. Remove the shipping strap, and install mounting base and motor as follows:

**CAUTION:** Motors larger than fifty horsepower must not be mounted on unit. Provide a floor mounted motor base for these motors. (Motor bases for motors larger than fifty horsepower are not furnished by Carrier.)

Motor Base 39AC7-A319

1. Bolt mounting base to fan section so that height adjusting slots are on side of motor base near fan shaft (Fig. 9), (Bolts are packaged in a bag attached to mounting base.)

**NOTE:** Make certain that motor mounting angles are arranged to allow motor shaft to extend beyond edge of fan section enough to permit alignment of sheaves. Slots in mounting angles are not centered, and allow correct positioning of a small motor at only one end of the mounting angles. If necessary, remove mounting angles and install them so that this end is near edge of fan section.

2. Mounting base can be arranged for several mounting height positions. Figure 13, page 20,
### Table 2 - 39AC7 Thru 14 Motor Bases

<table>
<thead>
<tr>
<th>Motor Base Part Number</th>
<th>Motor Range</th>
<th>39AC Unit Size</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hp</td>
<td>NEMA Frame Size</td>
</tr>
<tr>
<td>39AC7-A319</td>
<td>1 to 7-1/2</td>
<td>182 to 254U</td>
</tr>
<tr>
<td>39AC14-A319</td>
<td>3 to 20</td>
<td>256U to 286U</td>
</tr>
<tr>
<td>39AC14-A329</td>
<td>25 to 50</td>
<td>324U to 365U</td>
</tr>
</tbody>
</table>

**ST** = Standard Motor Base for this unit size  
**SP** = Motor Base available for this unit size on special order  
* Adapter 39W9-427 required

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**Fig. 9 - Mounting Base on Fan Section**

shows mounting base in minimum and maximum position. Determine mounting base position required, and adjust as follows:

a. Determine required center-to-center distance between fan shaft and motor shaft from drive package number and drive center distances listed in Table 3, page 24. (Drive package number is marked on drive end of fan section.)

b. Make cardboard pattern showing distance from foot of motor to center of motor shaft (Fig. 10).

c. Arrange mounting base so that support angles have slotted sides down (Fig. 11). Bolt support angles in center holes on motor base cradle and move height adjusting bolts to center of slots in cradle (Fig. 11).
Fig. 11 - Cardboard Pattern on Mounting Base

d. Place cardboard pattern on motor mounting angles and line up mark on pattern with notch in motor base cradle (Fig. 11).
e. Measure the distance between the center of the fan shaft and mark on cardboard pattern (Fig. 12).
f. If measurement exceeds required center-to-center distance (Table 3, page 24), lower support angles to bottom holes in motor base cradle. (This is minimum height position shown in Fig. 13, page 20.)

If measurement is less than the required center-to-center distance (Table 3, page 24), raise support angles to top holes in motor base cradle, and remeasure center distance. If measurement is still less than required center distance, remove motor mounting angles (Fig. 14) and turn support angles over so that slotted sides are up (Fig. 15). (This is maximum height position shown in Fig. 13, page 20).

Fig. 12 - Measuring Center-to-Center Distance

Fig. 13 - 39AC Motor Mounting Bases - Minimum and Maximum Heights
g. After motor base is set for correct distance, tighten support angle bolts.

3. Measure center-to-center distance between mounting holes on motor.

4. Set the motor mounting angles at measured center-to-center distance, and locate mounting angles so that motor shaft will be above center of notch in motor base cradle (Fig. 16).

5. Make certain that mounting angles are perpendicular to support angles, and tighten the mounting angle bolts.

6. Set motor on mounting angles so that motor shaft extends beyond edge of fan section enough to permit alignment of sheaves. Install motor mounting bolts finger tight. Do not tighten bolts until sheaves are aligned.
Fig. 14 - Support Angles Arranged for Minimum Height

Fig. 15 - Support Angles Arranged for Maximum Height

Fig. 16 - Motor on Mounting Base
Motor Base 39AC14-A319

The 39AC14-A319 motor base is similar to motor base 39AC7-A319 except for the addition of a jacking screw for adjusting the belt tension (Fig. 13, page 21).

1. Bolt mounting base to fan section so that captive nut for jacking screw is on side of motor base near fan shaft. (Bolts are packaged in a bag attached to mounting base.)

2. Adjust the mounting base and install the motor as described in Steps 2 thru 6 for motor base 39AC7-A319.

3. Install jacking screw and lock nuts as shown in Fig. 13, page 21.

Motor Base 39AC14-A329

The 38AC14-A329 motor base is similar to motor base 39AC7-A319 except for the addition of two jacking screws for adjusting the belt tension (Fig. 13, page 21).

1. Bolt mounting base to fan section so that captive nuts for jacking screws are on side of motor base near fan shaft. (Bolts are packaged in a bag attached to mounting base.)

2. Adjust the mounting base and install the motor as described in Steps 2 thru 6 for motor base 39AC7-A319.

3. Install jacking screws and lock nuts as shown in Fig. 13, page 21.

**NOTE:** If the motor base 39AC14-A329 is used on 39ACM9 and 10 size units, adapter 39W9-427 (Fig. 17) is required, bolt adapter to fan section using holes in base of adapter. Bolt motor base to adapter using threaded holes in adapter spacers.

**DRIVE PACKAGE**

The drive package number is stencilled on the drive package carton. This number must correspond with the drive package number marked on the drive end of the unit. Install drive package as follows:

**Sheaves**

Remove protective grease and tape from fan shaft and clean shaft carefully with solvent. Apply a light coat of grease or white lead to shaft, and install fan sheaves. Rotate fan shaft slowly by hand to make certain that fan wheels do not rub or bind.

Align sheaves as follows:

1. Adjust motor so that motor shaft is parallel to fan shaft.

2. Line up fan and motor sheaves and tighten screws on fan sheave to lock it in position.

3. Install fan belts on sheaves.

4. Check sheave alignment as shown in Fig. 18.
<table>
<thead>
<tr>
<th>Motor Hp Frame No</th>
<th>Drive Pkg No</th>
<th>Center Distances</th>
<th>Motor Hp Frame No</th>
<th>Drive Pkg No</th>
<th>Center Distances</th>
<th>Motor Hp Frame No</th>
<th>Drive Pkg No</th>
<th>Center Distances</th>
<th>Motor Hp Frame No</th>
<th>Drive Pkg No</th>
<th>Center Distances</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 182</td>
<td>-556</td>
<td>25.2 26.2</td>
<td>1-1/2 184</td>
<td>-556</td>
<td>26.0 20.0</td>
<td>3 213</td>
<td>-556</td>
<td>28.7 29.9</td>
<td>3 213</td>
<td>-556</td>
<td>32.4 33.6</td>
</tr>
<tr>
<td>1-1/2 184</td>
<td>-556</td>
<td>23.1 24.1</td>
<td>2 184</td>
<td>-556</td>
<td>26.2 27.2</td>
<td>5 215</td>
<td>-605</td>
<td>28.0 29.2</td>
<td>5 215</td>
<td>-605</td>
<td>31.3 32.5</td>
</tr>
<tr>
<td>2 184</td>
<td>-615</td>
<td>23.0 24.0</td>
<td>3 213</td>
<td>-616</td>
<td>28.7 29.7</td>
<td>10 256</td>
<td>-705</td>
<td>29.4 30.6</td>
<td>7-1/2 254U</td>
<td>-686</td>
<td>32.3 33.5</td>
</tr>
<tr>
<td>3 213</td>
<td>-566</td>
<td>23.0 24.0</td>
<td>5 215</td>
<td>-566</td>
<td>27.5 29.1</td>
<td>15 256U</td>
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<td>29.4 30.6</td>
<td>7-1/2 254U</td>
<td>-686</td>
<td>32.3 33.5</td>
</tr>
<tr>
<td>5 215</td>
<td>-566</td>
<td>24.0 25.0</td>
<td>10 256</td>
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<td>27.5 29.1</td>
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<tr>
<td>7-1/2 254U</td>
<td>-766</td>
<td>26.1 27.3</td>
<td>15 256U</td>
<td>-766</td>
<td>27.5 29.1</td>
<td>15 256U</td>
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<td>29.4 30.6</td>
<td>7-1/2 254U</td>
<td>-686</td>
<td>32.3 33.5</td>
</tr>
</tbody>
</table>

| 3 213            | -556        | 33.7 34.9        | 3 213           | -A106       | 36.4 37.1        | 5 215           | -556        | 40.7 41.7        | 7-1/2 254U      | -595        | 50.2 51.4        |
| 5 215            | -556        | 33.7 34.9        | 5 215           | -A106       | 36.4 37.1        | 10 256U         | -646        | 43.0 44.2        | 254U           | -596        | 49.8 50.8        |
| 7-1/2 254U       | -556        | 36.0 37.0        | 10 256U         | -646        | 43.0 44.2        | 15 256U         | -690        | 43.6 44.8        | 254U           | -596        | 49.8 50.8        |
| 10 256U          | -766        | 32.5 33.7        | 15 284U         | -766        | 43.0 44.2        | 20 286U         | -766        | 43.6 44.8        | 254U           | -766        | 49.8 50.8        |
| 20 286U          | -766        | 32.5 33.7        | 20 286U         | -766        | 43.0 44.2        | 25 324U         | -856        | 49.1 50.8        | 286U           | -856        | 49.1 50.8        |
| 25 324U          | -856        | 32.5 33.7        | 25 324U         | -856        | 43.0 44.2        | 30 325U         | -856        | 49.1 50.8        | 324U           | -856        | 49.1 50.8        |
| 30 325U          | -856        | 32.5 33.7        | 30 325U         | -856        | 43.0 44.2        | 40 344U         | -856        | 49.1 50.8        | 355U           | -856        | 49.1 50.8        |
5. If sheaves are not in correct alignment, adjust by repositioning motor.

6. Tighten motor hold-down bolts.

![Fig. 18 - Sheave Alignment](image)

**Belt Tension Adjustment**

1. On 39AC4 thru 6 size units, adjust the motor position by turning adjusting screw (Fig. 8, page 18).

   On units with 39AC7-A319 motor base, loosen four support angle bolts and adjust motor position by tipping motor base.

   On units with 39AC14-A319 or 39AC14-A329 motor base, loosen four support angle bolts and jacking screw lock nut(s), and adjust motor position by turning jacking screw(s).

   **WARNING:** Do not tip a sleeve bearing motor more than fifteen degrees from level position. Excess tipping will cause oil loss.

2. Check for proper belt tension by pressing belt with finger. Belt should deflect 1/2 inch at mid-point.

3. On 39AC7 thru 14 size units, after proper belt tension is acquired, tighten four support angle bolts (Fig. 19). On 39AC14-A319 and 39AC14-A329 motor bases, loosen jacking screw(s) and tighten jacking screw lock nut(s).

4. Drill holes in side of fan section to accommodate self-tapping sheet metal screws used to attach belt guard.

5. Install belt guard.

![Fig. 19 - Tightening Side Adjusting Bolts](image)

**Variable Pitch Motor Sheave**

The variable pitch motor sheave (Fig. 20) allows adjustment of fan speed by varying motor sheave pitch diameter. Remove fan belts and adjust pitch diameter as follows:

1. Loosen setscrew (Fig. 20) one quarter turn.

2. Turn adjusting screw (Fig. 20) clockwise to increase pitch diameter, or counterclockwise to decrease pitch diameter.

   **CAUTION:** Do not overload motor when changing pitch diameter to increase fan speed. Use snap-on ammeter to check motor load.

3. Tighten setscrew to lock sheave in position.

   Additional instructions for variable pitch sheave are included in drive package carton.

![Fig. 20 - Variable Pitch Motor Sheave](image)
ACCESSORIES

Humidifiers

Figures 2, 3, and 4 show the installed locations of the various humidifiers available for the 39AC Weathermaker. Install the humidifiers as follows:

Spray Humidifier

The spray humidifier is available for 39AC7 thru 14 size units. Bolt the spray humidifier section to the air-entering end of the cooling coil section as shown in Fig. 21. Install a solenoid valve or other suitable control device to shut off the sprays when the fan is not operating.

NOTE: If face and bypass dampers are used, provide minimum stops on face dampers to insure air flow thru the sprays at all times.

Fig. 21 - Spray Humidifier Bolted to Cooling Coil Section

Atomizing Spray Humidifier

The atomizing spray humidifier is available for all 39AC units. Refer to Fig. 22, and proceed as follows:

1. Provide an opening on each side of the unit.
   a. Short horizontal units:
      (1) On 39AC4 thru 6 size units, use existing holes in fan section.
      (2) On 39AC7 and 8 size units, cut a 4-1/4 inch diameter hole in each side of the fan section.
      (3) On 39AC9 thru 12 size units, cut a 7 inch diameter hole in each side of the fan section.
   b. Standard horizontal and vertical units:
      (1) On 39AC4 thru 6 size units, use existing holes in plenum section.
      (2) On 39AC7 size unit, cut a 4-1/4 inch diameter hole in each side of the coil section.
      (3) On 39AC8 thru 12 size units, use existing access openings in end panels.
      (4) On 39AC13 thru 14 size units, cut a 7 inch diameter hole in each side of coil section.

2. Drill holes at humidifier openings to match holes in humidifier cover plates.

3. Mount spray pipe support brackets so that center line of spray pipe will pass thru center of access opening.

4. Place spray header assembly on support brackets with spray nozzles facing against direction of air flow.

5. Secure spray pipe to support brackets with hold-down bolts.

6. Install humidifier cover plate using self-tapping screws.

Steam Grid Humidifier

The steam grid humidifier is available for all 39AC units. Refer to Fig. 23, and proceed as follows:

1. Provide an opening on each side of the unit.
   a. Short horizontal units:
      (1) On 39AC4 thru 6 size units, use existing holes in fan section.
      (2) On 39AC7 and 8 size units, cut a 4-1/4 inch diameter hole in each side of fan section.
      (3) On 39AC9 thru 12 size units, cut a 7 inch diameter hole in each side of fan section.
Fig. 22 - Atomizing Spray Humidifier Installation
Fig. 23 - Steam Grid Humidifier Installation
b. Standard horizontal and vertical units:

(1) On 39AC4 thru 6 size units, use existing holes in plenum section.

(2) On 39AC7 size unit, cut a 4-1/4 inch diameter hole in each side of the coil section.

(3) On 39AC8 thru 12 size units, use existing access openings in end panels.

(4) On 39AC13 thru 14 size units, cut a 7 inch diameter hole in each side of coil section.

2. Drill holes at humidifier openings to match holes in humidifier cover plates.

3. On 39AC4 thru 11 size units, install humidifier with 1/4 inch pitch toward drain. On 39AC12 thru 14 size units, install humidifier with 1/2 inch pitch toward drain.

4. Cement insulation to inside surface of cover plate, and install plate using 1/4-20 screws.

**Bypass Duct and Duct Extensions**

Figure 25 shows the installation procedure for bypass ductwork on horizontal units. On vertical units, if a duct extension is to be used, remove the lower portion of the fan section back panel to provide an inlet for bypass air. (On vertical units with reheat coil, the bypass air inlet is provided in the bypass heating coil section.) Attach the duct extension to the fan section at the bypass air inlet.

**NOTE:** On horizontal units, if bypass ductwork is used, fan motor cannot be mounted on top of fan section.

**Face and Bypass Dampers**

Bolt the face damper section of the damper assembly (Fig. 24) to the air-entering end of the unit. Bolt the bypass damper section of the assembly to the bypass ductwork. On vertical units without duct extensions, remove the lower portion of the fan section back panel to provide an inlet for bypass air. (On vertical units with reheat coil, the bypass air inlet is provided in the bypass heating coil section.) Bolt the bypass damper section to the fan section at the bypass air inlet.

**CAUTION:** When lifting damper assembly, provide support under center of assembly to prevent sagging.

**Plenum**

Bolt plenum section to air-entering end of face and bypass damper assembly (Fig. 24).

**Fig. 24 - Face and Bypass Dampers and Plenum**

**Auxiliary Heating Coil Section**

If the auxiliary heating coil section is to be used as a preheat coil section, bolt the section to the air-entering end of the unit.

**NOTE:** If preheat coil section is to be used with a reheat coil, and face and bypass dampers, install preheat section on air-entering end of plenum to prevent freezing of reheat coil.

On vertical units, if the auxiliary heating coil section is to be used as a reheat coil section, bolt the section to top of the cooling coil section before lifting the fan section into position.

**Filter Section**

The high and low velocity filter sections are shipped completely assembled. Bolt the filter section to the air-entering end of the unit.

**Mixing Box**

The separate mixing box is used on 39AC4 thru 6 size units. Bolt the mixing box to the air-
1. Remove Coil Section Top Panel

2. Install Bypass Duct Side Panels

3. Bolt Bypass Duct Top Panel

4. Install Bypass Duct Extension

5. Secure All Bolts to Complete Installation

Fig. 25 - Bypass Duct Installation
entering end of the unit. The bottom of the mixing box is not flush with the bottom of the base unit. The shipping support angle provided under the factory-installed accessories can be used to support the mixing box on floor-mounted units. Relocate this support angle under the outside flange of the mixing box.

Combination Mixing Box and Filter Assembly

The combination mixing box and filter assembly (Fig. 26) is used on 39AC7 thru 14 size units. Bolt the assembly to the air-entering end of the unit. The bottom of the mixing box and filter assembly is not flush with the bottom of the base unit. A spacer (not factory furnished) must be installed under the assembly for support (Fig. 27). Holes are provided in the bottom of the assembly for attaching the spacer. Table 4 gives the distance between the mounting surface and the bottom of the mixing box and filter assembly.

Table 4 - Distances Between Mounting Surface and Bottom of Combination Mixing Box and Filter Assembly

<table>
<thead>
<tr>
<th>Unit Size</th>
<th>Distance (Inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>39AC7</td>
<td>4-1/8</td>
</tr>
<tr>
<td>39AC8</td>
<td>4-1/8</td>
</tr>
<tr>
<td>39AC9</td>
<td>4-1/8</td>
</tr>
<tr>
<td>39AC10</td>
<td>4-1/8</td>
</tr>
<tr>
<td>39AC10,5</td>
<td>4-1/8</td>
</tr>
<tr>
<td>39AC11</td>
<td>4-1/8</td>
</tr>
<tr>
<td>39AC12</td>
<td>4-1/8</td>
</tr>
<tr>
<td>39AC13</td>
<td>7-1/2</td>
</tr>
<tr>
<td>39AC13,5</td>
<td>8</td>
</tr>
<tr>
<td>39AC14</td>
<td>8</td>
</tr>
</tbody>
</table>

Filter Section Blank-Off Baffles

If high velocity filters are used in the low velocity filter section or combination mixing box and filter assembly, install blank-off baffles in the filter tracks along with the filters. Distribute the baffles evenly along the tracks to insure uniform air distribution.

Bypass Heating Coil Section

The bypass heating coil section is used on 39AC7 thru 14 size vertical units as a reheat coil section. Bolt the section to the top of the cooling coil section before lifting the fan section into position.

CEILING SUSPENSION

If a 39AC4 thru 12 size horizontal unit is to be ceiling-suspended, use the accessory suspension clip package. Install suspension clips on top of the unit using the mounting holes provided. On 39AC4 thru 6 size units, a suspension clip is required at each of the four corners of the base unit. On 39AC7 thru 12 size units, a suspension clip is required at each of the four corners of the coil section, and at each of the two outside corners of the fan section. Lift the unit into position and extend a ceiling-anchored tie rod (not factory furnished) thru each suspension clip.

The 39AC13 thru 14 size units must be suspended on a platform.
Fig. 28 - Direct Expansion Cooling Coil Piping Connections
OUTDOOR INSTALLATION

1. Fill all areas of unit with waterproof material where water might collect or leak into unit. Crown top of unit with waterproof material to insure proper water drainage.

2. If outside temperature will be below dew-point of air in unit at any time during operating season, insulate unit. Vapor seal and weatherproof the insulation.

3. Have motor manufacturer recommend a motor type suitable for outdoor use.

4. Use water deflecting shield to protect fan shaft bearings and drives.

5. If unit is to be subjected to freezing temperatures, take precautions to protect coils and drains from freeze-up (see "Coil Freeze Protection," page 36).

PIPING CONNECTIONS

Pipe unit so that vibration is not transmitted to or from unit.

Direct Expansion Cooling Coil

Figure 28 shows recommended piping methods for direct expansion cooling coils. Units are shipped from the factory with right-hand coil connections unless left-hand connections are specified on the order. (When facing air inlet end of unit, liquid and suction connections are on right-hand side of unit.) To change unit for left-hand connections, rotate coil 180 degrees in vertical plane.

On unit with right-hand connections, 1/2 inch ODF connections on coil are for external equalizer lines to expansion valves. Equalizer lines compensate for pressure drop across coil and equalize pressure to expansion valves.

On unit with left-hand connections, 1/2 inch ODF connections on coil are for oil return lines to suction risers. Oil return lines should be 3/8 inch OD copper tubing. Return lines insure return of oil to suction line at partial loading. Without oil return line, decreased gas velocity in suction header at partial loading may cause oil to be trapped in bottom tubes of coil. This may result in compressor failure due to insufficient lubrication. Use of oil return lines does not eliminate need for double suction risers when required. Expansion valve equalizer lines are connected to suction line on left-hand units.

Refrigerant distributor nozzles supplied are suitable for average load conditions. If load is very light or very heavy, substitute correct nozzles. Select nozzles according to recommendations of a qualified engineer. Check nozzles as follows:

1. Remove seal cap from refrigerant distributor, and check marking on orifice nozzle inside distributor to make certain nozzle is correct as specified by the engineer selecting the equipment.

2. If correct nozzle is in place, record nozzle number on warning label attached to coil cover plate (Fig. 29). If correct nozzle is not in place, change as follows:
   a. Remove retainer ring, and insert two Number 7-32 screws in holes provided.
   b. Remove nozzle by gripping heads of these screws.
   c. Place correct nozzle in distributor with marking visible.
   d. Replace retainer ring in groove.
   e. Record nozzle number on warning label attached to coil cover plate.

**WARNING**

READ BEFORE REMOVING COIL CAPS

THIS COIL IS EQUIPPED WITH REFRIGERANT DISTRIBUTOR(S) ADJUSTABLE FOR LOAD BY CHANGING ORIFICE NOZZLE(S) NOZZLE(S) SUITABLE FOR AVERAGE COIL LOAD WAS INSTALLED AT THE FACTORY IF LOAD IS EITHER VERY LIGHT OR VERY HEAVY PROPER NOZZLE(S) MUST BE SUBSTITUTED SELECTION BY QUALIFIED ENGINEER IS RECOMMENDED UPON INSPECTION MARK HERE WITH BALL POINT PEN

NOZZLE NO. USED

(SEE MARKING ON FACE OF NOZZLE)

![Fig. 29 - Warning Tag](image-url)

Solder expansion valve to outside of refrigerant distributor body. If bulb of thermostatic expansion valve is located above valve body, capillary tubing must be looped as shown in Fig. 28 to trap the charge in the bulb.

If all piping is the same size, suction risers must be looped into main suction header as shown in Fig. 28 to prevent drainage of oil back to coil. Suction line must be looped above top of coil to prevent drainage of liquid refrigerant into compressor during shutdown.
Water Cooling Coil

Figure 30 and 31 show water coil piping connections. Install supply pipe on air-leaving end of coil, and return pipe on air-entering end of coil, install a tee with a pipe plug at cooling coil connections to facilitate blowing of air thru coil for freeze protection.

**Fig. 30 - Water Coil Piping Connections**

**DISCHARGE DUCT CONNECTIONS**

Figure 32 shows several discharge duct arrangements. Install flexible connections at fan outlets or between transformation piece and ductwork to prevent transmission of vibration from unit to duct system. Make certain that angles on transformation piece are no greater than fifteen degrees (Fig. 32).

**Condensate Drain and Gutter Drain**

Connect a drain line to one condensate drain connection as shown in Fig. 31, and cap the other drain connection. Connect a drain line to both 1/2 inch MPT connections in the gutter drain. Run these drain lines to the nearest open sight drain.

**Fig. 31 - Cooling Coil Condensate Piping and Drain Trap**

**FINAL INSTALLATION CHECK LIST**

Prior to start-up, check the following:

1. Make certain all construction debris is removed from interior of unit.
2. Check lubrication of fan bearings.
3. Check lubrication of motor bearings.

**NOTE**: Sleeve bearing motors are normally shipped with oil reservoir drained. Fill oil reservoir before running motor.

4. Check setscrews in bearing locking collar. Vibration during shipment may loosen the setscrews.
5. Recheck sheave alignment and belt tension.
6. Make certain fan shaft turns freely and fan wheels do not rub in housings.
7. Check fan speed and direction or rotation. The red arrow on drive side of the fan section indicates correct direction or rotation. Excessive fan speed may result in carryover of condensate from cooling coil and overloading of fan motor. Table I gives maximum fan speeds.
NOTES:
1 INSTALL DUCTS SO AIR FLOW IS IN DIRECTION OF FAN ROTATION
2 AREA AT SUPPLY DUCT TAKE-OFF MUST BE EQUAL TO OR GREATER THAN AREA OF FAN DISCHARGE
3 NO ANGLE ON TRANSFORMATION FITTING CAN BE GREATER THAN 15°

Fig. 32 - Discharge Duct Arrangements
Another method of freeze protection is use of antifreeze. Any inhibited antifreeze, acceptable to code and underwriter authorities, may be circulated with residual water in coil, then drained off and reused until its dilution approaches minimum concentration required for safety.

To flush coils with antifreeze, proceed as follows:

1. Shut off supply and return water piping.
2. Drain coil, using drain and vent connections provided.
3. Connect a small centrifugal pump to drain connection of coil.
4. Run a return line from coil vent connection thru a throttling valve to a container which will act as a sump for antifreeze.
5. Run a line from antifreeze container to pump.
6. Start solution pump with throttling valve about one quarter open.
7. Circulate solution for about fifteen minutes; then check its strength.
8. If solution is too weak, add antifreeze to bring solution up to desired strength, and circulate thru coil for about fifteen more minutes.
9. When concentration of solution returning from coil is satisfactory, shut down pump and drain antifreeze from coil.
10. Same solution may be used to flush additional coils, provided its concentration is maintained.

**FAN SECTION**

**Fan Bearings**

Low pressure units have self-aligning ball bearings with cast iron flanged bearing blocks. An open end bearing is used on drive end of fan shaft. A closed end bearing is used on free end of fan shaft.

On medium pressure units, bearing on drive end of fan shaft has a cast iron flanged bearing block. Bearing on free end of fan shaft
MAINTENANCE

has a rubber pillow block. Open end ball bearings are used on both ends of fan shaft.

To remove bearings:

1. Remove fan sheave.
2. Loosen bearing setscrews.
3. Remove bolts that fasten bearing flange to bearing plate.
4. Remove bearing from fan shaft.

CAUTION: Do not let machined surface of fan shaft drop on fan bearing plate.

To replace bearings, reverse above procedure.

Fan Shaft Removal

1. Remove belt guard, fan belts, and fan sheave.
2. Loosen fan clamps. (On 39AC4 thru 6 size units, remove fan section front or top panel for access to clamps.)
3. Remove fan bearings.
4. Remove bearing plate from end of fan section thru which shaft is to be removed. On low pressure units, shaft can be removed from either end of unit. On medium pressure units, shaft must be removed from drive end of unit.
5. Slide shaft out of unit.

CAUTION: Do not let fan wheels drop when removing fan shaft.

To install new fan shaft, reverse the above procedure.

Fan Wheel Removal

1. On 39AC4 thru 6 size vertical units, remove center portion of fan section front panel. On all other 39AC units, remove fan section top panel, or discharge ductwork. This provides access to fan wheels.
2. Remove fan shaft. After shaft is removed, fan wheels will rest on bottom of fan scrolls.
3. Unscrew fan scroll bolts, and remove scroll from unit.
4. Unscrew cutoff plate fasteners from scroll, and remove cutoff plate.
5. Remove fan wheel thru discharge opening of scroll.

To install new wheel, reverse above procedure. Position wheel in scroll so that there is an equal amount of clearance on both sides of wheel. Adjust cutoff clearance (Fig. 35) at 1-1/4 inches for 39AC4 thru 12 size units and 1-1/2 inches for 39AC13 thru 14 size units.

Motor Sheave

Adjust fan speed by varying motor sheave pitch diameter. Remove fan belts, and adjust pitch diameter as described under "Variable Pitch Motor Sheave," page 25.

Fan Belts

Check fan belts at least twice a year for excessive wear, proper tension, alignment, and accumulation of grease and oil. Do not use belt dressing.

LUBRICATION

Fan Bearings

The standard fan bearings are prelubricated at the factory. When lubrication becomes necessary, follow the lubrication instructions on the
unit lubrication plate (Fig. 34). The following lubricants are approved equivalents of Carrier PP80-10 multipurpose grease:

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Lubricant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sun Oil Company</td>
<td>Prestige 42</td>
</tr>
<tr>
<td>Texas Company</td>
<td>Multifak 2</td>
</tr>
<tr>
<td>Socony Mobil Oil Company</td>
<td>Mobilplex EP No. 1</td>
</tr>
</tbody>
</table>

For optional sleeve bearings, refer to lubrication instructions provided by the bearing manufacturer.

Motor Bearings

Refer to lubrication instructions provided by motor manufacturer.

FILTERS

Inspect filters periodically, and replace when necessary. A sensitive manometer provides an accurate method of determining filter condition. Install manometer with pressure connections attached to filter casing, one upstream and one downstream from filter bank. Dirt in filter will appreciably increase pressure drop across filter. To replace filters, proceed as follows:

1. Remove cover plates from both ends of filter box.
2. Remove half of filter bank from each end of filter box.
3. Install new filters in filter bank.
4. Make certain filter track is completely filled to prevent bypass of unfiltered air.
Carrier Dealers, Distributors, and Field Offices are listed in the Yellow Pages. Their experience is at your service.
# 39AC DRAW-THRU CENTRAL STATION WEATHERMAKER

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGINEERING FEATURES</td>
<td>2</td>
</tr>
<tr>
<td>ENGINEERING DATA</td>
<td>4</td>
</tr>
<tr>
<td>ARRANGEMENTS</td>
<td>6</td>
</tr>
<tr>
<td>SELECTION PROCEDURE</td>
<td>8</td>
</tr>
<tr>
<td>UNIT SELECTION</td>
<td>9</td>
</tr>
<tr>
<td>COOLING COIL SELECTION</td>
<td>11</td>
</tr>
<tr>
<td>Chilled Water Coils for Heating</td>
<td>12</td>
</tr>
<tr>
<td>Removable Header Water Coils</td>
<td>12</td>
</tr>
<tr>
<td>Coil Performance</td>
<td>13</td>
</tr>
<tr>
<td>Conversion Charts</td>
<td>14</td>
</tr>
<tr>
<td>Direct Expansion Coil</td>
<td>16</td>
</tr>
<tr>
<td>Selection Example</td>
<td>17</td>
</tr>
<tr>
<td>Coil Ratings</td>
<td></td>
</tr>
<tr>
<td>Chilled Water Coil</td>
<td>22</td>
</tr>
<tr>
<td>Selection Example</td>
<td>23</td>
</tr>
<tr>
<td>Coil Ratings</td>
<td></td>
</tr>
<tr>
<td>HEATING COIL SELECTION</td>
<td>56</td>
</tr>
<tr>
<td>Hot Water Coil</td>
<td>56</td>
</tr>
<tr>
<td>Selection Example</td>
<td>57</td>
</tr>
<tr>
<td>Coil Ratings</td>
<td></td>
</tr>
<tr>
<td>Steam Coil</td>
<td>62</td>
</tr>
<tr>
<td>Selection Example</td>
<td>63</td>
</tr>
<tr>
<td>Coil Ratings</td>
<td></td>
</tr>
<tr>
<td>ACCESSORY SELECTION</td>
<td>65</td>
</tr>
<tr>
<td>FAN PERFORMANCE</td>
<td>66</td>
</tr>
<tr>
<td>Selection Example</td>
<td>66</td>
</tr>
<tr>
<td>Apparatus Resistance</td>
<td>67</td>
</tr>
<tr>
<td>Fan Ratings</td>
<td>67</td>
</tr>
<tr>
<td>PHYSICAL DATA</td>
<td>74</td>
</tr>
<tr>
<td>DIMENSIONAL DATA</td>
<td>75</td>
</tr>
<tr>
<td>SPECIFICATIONS</td>
<td>82</td>
</tr>
</tbody>
</table>

Carrier Air Conditioning Company, Syracuse, N.Y.
Carrier Draw-Thru Central Station
Weathermaker

For Single Zone Applications

Chilled Water and Brine Coil
(Omit when DX is used)

The cooling coil shall be designed for use with chilled water (brine as the refrigerant with freezing point S F) and a maximum working pressure of 300 psig. The Grand Total Heat capacity shall be not less than ____ Btu/hr when handling ____ cfm of air at an entering water (brine) temperature to the coil of ____ F under the following conditions:

<table>
<thead>
<tr>
<th>Dry-Bulb</th>
<th>Wet-Bulb</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>F</td>
</tr>
</tbody>
</table>

Air entering coil ____ F
Air leaving coil ____ F

The water (brine) circulation rate shall be ____ gpm at a maximum pressure drop thru the coil of ____ feet of water. Connections shall be provided for convenient water drainage and air venting of the coil, and all connections shall be threaded. (Provide a full circuated removable header type coil for the service indicated above for a maximum working pressure of 100 psig.)

Heating Coils

Heating coils shall be of copper tubes with helically wound fins of aluminum (copper). They shall be nonaseemless (return bend type for use with hot water or steam) designed for a maximum working pressure not to exceed 200 psig and 400 F. They shall be the cartridge type and shall be arranged for right (left) end piping connections. All connections shall be located at the same end of the coil. The capacity of the heating coil shall be ____ Btu/hr at an entering air temperature of ____ F, when handling ____ cfm of standard air.

1. (Omit when hot water coil is used.) The coil shall be supplied with ____ psig steam.

2. (Omit when steam coil is used.) The entering water temperature shall be ____ F at a circulation rate of ____ gpm and a maximum pressure drop thru the coil of ____ feet.

Accessories

A ____ hp, frame ____ 1750 rpm, ____ volt, ____ phase, ____ cycle electric motor shall be provided to drive the fan.

A heating coil section of galvanized steel shall be provided for the heating coil.

A mixing box of galvanized steel shall be supplied with interconnected, double acting damper blades on two wheel units and single acting damper blades on single wheel units for mixing outside and return air.

A low velocity (high velocity) filter section of heavy gauge galvanized steel shall be supplied. Filters shall be removable from either end of the filter section.

An atomizing spray (steam grid) humidifier shall be provided.

Suspension clips shall be provided for suspending the unit(s).

A bypass damper section of galvanized steel shall be supplied. The dampers shall be of the double acting type, balanced, and supported at both ends by nylon sleeve bearings.

A bypass plenum section of galvanized steel shall be supplied.

A bypass duct of galvanized steel shall be supplied.

A bypass heating coil section that will allow air to bypass around the cooling coil or around the cooling coil and heating coil shall be supplied (for vertical units only).

This catalog contains information for product application only. Refer to the Carrier System Design Manual or consult your nearest Carrier office for general information on design of the complete system.
SPECIFICATIONS for the guidance of architects and consulting engineers

The contractor shall furnish and install 39AC carrier model 39AC central station weathermakers. The casing shall be constructed of heavy gauge mill-tempered sheet steel which are reinforced with angles or channels. The casing panels shall be removable for easy access to the interior. Insulation for the fan section, cooling coil section, and heating coil section shall be covered one-inch fire resistant glass wool blanket. The condensate drain pan shall be equipped with one-half inch sheet of waterproof expanded plastic fastened to the pan. The coil connections shall be on the right (left) end of the unit when facing the entering air side of the unit. The fan drive shall be on the right (left) end of the unit when facing the entering air side of the unit. The motor shall be mounted on the top (front) of the fan section.

The basic unit shall consist of a fan section, a condenser drain pan, cooling coil section, fan drive package with variable pitch pulley and V-belts, and universal type adjustable motor base.

In addition, the following accessories shall be supplied (select only items required):

1. Motor
2. Heating coil section
3. Bypass heating coil section
4. Mixing box
5. Low velocity filter section
6. High velocity filter section
7. Steam grid humidifier
8. Atomizing spray humidifier
9. Spray humidifier
10. Suspension clips
11. Bypass damper section
12. Plenum section
13. Bypass duct assembly
14. Bypass duct extensions

Fan Section

Fans shall be of the forward-curved blade type, statically and dynamically balanced. Shafts for single wheel units shall be solid, full diameter steel, accurately finished for standard ball bearings. Bearings shall be factory-lubricated and of the self-aligning type. The centrifugal fan shall deliver 0.001 cfm against a total static pressure of inches of water gage. The fan shall be operated well below critical speed at not more than 1400 rpm by not less than a horsepower motor. Units shall be tested in accordance with AMCA Bulletin 210. Fan sections shall be designed for discharge.

Cooling Coils

The cooling coil shall be constructed of copper tubes with helically wound fins of aluminum (copper). Aluminum fins shall be tightly wound and mechanically bonded to a copper tube. Copper fins to be bonded by a complete solder coating of the fins and tube. Coil(s) shall be four (six) (eight) rows with nominal fin spacings of eight (fourteen) fins per inch. Coils shall be of the cartridge type for ease of installation and shall be reversible for right or left and piping connections. Both the supply and return connections shall be located on the same end.

Direct Expansion Coil (Oni when chilled water is used)

The coils shall be designed for direct expansion operation, using refrigerant and a maximum working pressure of 300 psi. The Grand Total Heat capacity shall be not less than Btu/hr when handling 0.001 cfm of air at a saturated refrigerant suction temperature at the coil outlet of 1 F, under the following conditions:

<table>
<thead>
<tr>
<th>Dry-Bulb</th>
<th>Wet-Bulb</th>
</tr>
</thead>
<tbody>
<tr>
<td>At entering coil</td>
<td>F</td>
</tr>
<tr>
<td>At leaving coil</td>
<td>F</td>
</tr>
</tbody>
</table>

Pressure type liquid distribution shall be used and coil headers shall have gravity oil drainways. Piping connections shall be of the solder type.

ENGINEERING FEATURES

39AC draw-thru central station weathermakers for single zone applications are available in 11 sizes. 39AC thru 6 units handle 600-3500 cfm at up to 3 inch total static pressure. 39AC thru 14 units handle 4500-4500 cfm and are available as a low pressure unit up to 4 inch static pressure or as a medium pressure unit for static pressures between 4 and 7 inches.

Arrangements for flexibility in design are featured with the 39AC single zone weathermaker. Numerous arrangements are available to suit almost any design criteria for the unique building block design which enables unit sections and accessories to be fitted together in many different ways. Typical 39AC arrangements on pages 6 and 7 will help the designer select unit components for his application.

The following features are illustrated on the opposite page.

1. Removable Casing Panels constructed of heavy sheet metal, flanged and reinforced as required. All framing and paneling members of all components and accessories are protected by galvanized finish.

2. Universal Motor Base furnished for range of motor sizes. May be mounted on either side of unit, on top (shown) or front of fan section. Variable pitch pulleys and V-belts available for wide range of fan speeds. Belt guard is furnished.

3. Insulation of fan section, cooling coil sections, and all accessories downstream from the cooling coil consists of coated one-inch glass wool blanket applied at the factory. No field insulation required.

4. Drain Pan Insulation consists of half-inch sheet of waterproof expanded plastic securely fastened to the pan.

5. Fan Wheels are forward-curved blade type for unit compactness, statically and dynamically balanced. Their maximum rated speed is well below the critical speed. Fan shaft bearings are the factory-lubricated, self-aligning ball type.

6. Heating Coils are available in non-frost type for use with steam or the return head type for use with steam or hot water. Tightly wound mechanically bonded aluminum fins or solder coated copper fins may be specified. All coils are of the cartridge type for ease of installation and are reversible for right or left and piping connections. Supply and return connections are located on the same end.

7. Cooling Coils are constructed of copper tube with a choice of helically wound aluminum or copper fins. Selection may be made from 4-, 6-, or 8-row coils, with nominal fin spacings of either 8 or 14 fins per inch. Aluminum fins are tightly wound and mechanically bonded on the tube; copper fins are bonded by a complete solder coating of the fins and tube. The coils are the reversible cartridge type which slide in or out of the coil section on tracks. Both direct expansion or chilled water coils are offered. Removable header type chilled water and brine coils are also available. Supply, return, vent, and drain connections are located on the same end.

8. Accessories such as filter sections, face and bypass dampers, mixing boxes, separate heating coil sections and humidifiers, when added to the basic building block of fan and cooling coil section, give truly flexible arrangements.
UNIT APPLICATION

All 39AC Single Zone Westermakers may be obtained for either horizontal or vertical installation. In either case, the system designer may choose from a number of different arrangements of components and accessories to meet the specific requirements of his project. He also has a choice of air discharge direction, fan motor location and right or left side coil connections.

This flexibility of arrangement is achieved largely thru adoption of the building block principle of design. The component and accessory "building blocks" may be fitted together in various ways (page 6 - 7). Dimensional drawings (pages 75 - 81) used in conjunction with the instructions mentioned above, help establish the space required for the various arrangements. They also show component sizes in case disassembly is required at the job to allow passage thru an opening too small for the unit as shipped.

Horizontal Application - 39AC4 thru 6

The 39AC4 thru 6 units use a cooling coil section so that, when combined with a condensate pan, fan section, plenum section and/or heating coil section, it forms a unit with or without simultaneous dehumidification and reheating up to the maximum of 700fpm coil face velocity. Pages 75 thru 77 show how the cooling coil section is combined with other unit components such as fan section, heating coil section, plenum, condensate pan and accessories.

Horizontal Application - 39AC7 thru 14

Two different cooling coil sections are available for horizontal installations (page 5).

The standard coil section is fitted with tracks to accommodate an optional heating coil. A condensate pan that fits under the coil section only is supplied with this arrangement. Use of the standard coil section with heating coil permits simultaneous dehumidification and reheating up to the maximum 700 fpm coil face velocity.

The short coil section for sizes 7 thru 12 is supplied with a longer condensate pan that fits under both the short cooling coil section and the fan section. This arrangement results in a very compact unit but does not permit simultaneous dehumidification and reheating. However, a heating coil, housed in a preheat coil section, may be added upstream of the cooling coil for winter service.

The system designer may specify either type of cooling coil section, less the coil, in cases where user desires a heating and ventilating system to which cooling may be added easily at a later date.

Vertical Application - 39AC4 thru 6

The 39AC4 thru 6 vertical arrangement uses the cooling coil section, plenum, short condensate pan, and fan section to form the basic unit. A vertical reheat coil section can be used between the fan and cooling coil sections. This permits simultaneous dehumidification and reheating. A preheat coil section is added for heating if required.

Vertical Application - 39AC7 thru 14

The standard cooling coil section must always be used here. In the vertical arrangement the heating coil cannot be located to the standard cooling coil section. It must be housed in one of the heating coil sections. It can be positioned either upstream (as preheat) to the standard cooling coil section or downstream in between the standard cooling coil section and the fan section. The latter arrangement permits simultaneous dehumidification and reheating up to the maximum 700 fpm coil face velocity.
Face and Bypass Control

An optional face and bypass damper section has been designed to fit externally to the cooling coil section, so as to avoid unnecessary bulk when this control is not required. In horizontal applications, the face and bypass damper section requires the use of a short external duct section so air can be bypassed over (1) the cooling coil or (2) the pre-cool and cooling coils. In vertical applications an external duct section is not required (unless a pre-cool section is attached to the cooling coil section) with the face and bypass damper section, as air can be introduced directly into the fan section, once a removable panel is unbolted from the fan section.

When vertical face and bypass control is desired in conjunction with a summer cooling and reheat application, the heating coil section must provide the inlet and space for the bypass air to circulate thru the unit. For this particular application, a supplementary section, called a "bypass heating coil section", is provided. When either vertical or horizontal units are arranged for summer cooling and winter heating, control of both cooling and heating coils may be achieved with the face and bypass damper.

Floor Mounting and Suspension

The 39AC Single Zone Weathermaker may be mounted on rubber-in-shear or spring vibration isolators, or mounted without vibration isolation, depending upon job requirements. Sizes 4 thru 12 may also be suspended using standard suspension clips to which the installer fastens hanger rods. Larger size units may be supported on suspended platforms if desired. On installations where units are installed close to occupied areas or on upper floors, care should be taken to properly isolate the unit from the building structure and connecting ductwork with vibration isolation and canvas connections. Medium pressure units with their higher fan speeds should be given special consideration from an isolation standpoint.

Sound Control

Any piece of rotating equipment generates sound. Whether this sound is disturbing depends on the particular job requirements and, therefore, any sound control or attenuation must be handled on an individual job basis. Duct treatment in the form of sound traps or sound absorbers, and flexible connections on the supply as well as on the return sides of the unit should be considered as required by good design practice.

Other Accessories

Arrangement of other accessories, such as low or high velocity filter sections and mixing boxes, follows the same building block principle discussed above and is illustrated on the following pages.

Fan Discharge

The fan sections of 39AC units have been designed so that the air discharge outlet may be located in any one of several positions, either in horizontal or vertical applications. Outlet arrangements are illustrated on pages 73-81.

Motor Mounting Positions

The fan section has been designed so the motor may be located on either the left or right hand side of the unit, on the front or on top of the fan section. When the external bypass duct is used, the top motor mounting position is not available on all unit sizes and arrangements.
TYPICAL ARRANGEMENTS OF 39AC COMPONENTS, ACCESSORIES AND DISCHARGES

HORIZONTAL
1. Cooling coil section, fan section, long drip pan. For summer cooling only (XX) or summer cooling and winter heating using chilled or hot water.

2. Preheat coil section, cooling coil section, fan section, long drip pan. Summer cooling, winter heating, each with its own coil.

3. Cooling coil section fitted with cooling and heating coils, fan section, short drip pan. For summer cooling with reheat, winter heating.

4. Accessories such as the combination mixing box and filter section may be used with any 39AC unit.

5. Cooling coil section, fan section, short drip pan. For summer cooling only (XX) or summer cooling and winter heating using chilled or hot water.

VERTICAL
6. Preheat coil section, cooling coil section, fan section, short drip pan. Summer cooling, winter heating, each with its own coil.

7. Cooling coil section, reheat coil section, fan section, short drip pan. For summer cooling with reheat, winter heating.

8. High velocity filter section with cleanable filters may be used with either the vertical or horizontal unit.

9. Some arrangement and functions as No. 1, but with face and bypass dampers and external bypass duct added to provide this control.

HORIZONTAL (BYPASS)
10. Some arrangement and functions as No. 2, but with face and bypass dampers. External duct permits bypass of heating and cooling coils.

11. Some arrangement and functions as No. 3, but with face and bypass dampers. Duct permits bypass of cooling coil, not heating coil.

NOTE:
The arrangements shown here by no means exhaust the potential for variation permitted by 39AC equipment. The illustrations presented here and the dimensional drawings on pages 15 thru 81 suggest many other possibilities.

39AC7 THRU 12 HORIZONTAL
"W" REQD. FOR COIL AND FAN SHAFT REMOVAL EITHER END

39AC13, 14 HORIZONTAL
"W" REQD. FOR COIL AND FAN SHAFT REMOVAL EITHER END

NOTE:
1. Cooling and heating coils can be staggered for either right or left and position connections.
2. Water and air can be controlled in either top or front, right or left side of unit.
3. See Technical Data tables for number of digits expansion of these and other connections.
VERTICAL (BYPASS)

12. Some arrangement and functions as No. 5, but with face and bypass dampers. Note in this setup an external bypass duct is needed.

13. Some arrangement and functions as No. 6. Here a small sheet metal adapter is required to complete the installation of the bypass.

14. Some arrangement and functions as No. 7. Here a bypass heating coil section is required to provide an inlet for the bypass air.

15. Some arrangement and functions as No. 14, except heating coil position is changed so air will bypass both heating and cooling coils.

SIZES AND NOMINAL CAPACITIES

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NOTES:
1. Cell capacities are based on maximum air quantity and the cooling coil 1900 ft³/hr air velocity and 70°F entering water temperature. Cylindrical factor and direct expansion cells are based on 45°F minimum circuiting condition.
2. All capacities must be determined for specific unit conditions.
3. Actual cell capacities should be determined for specific job conditions.

*Carrier* 39AC
SELECTION PROCEDURE

Engineering information and detailed selection procedures, charts and ratings are given in the following pages. If any phase of air conditioning is not needed, the step for that phase should be eliminated from the selection procedure.

Select equipment as follows:

Step 1 – Select Unit Size (pages 9 and 10)

A unit is selected from 11 sizes and the total cfm range of 600 – 40,750. This unit size is then used in subsequent steps in selecting the unit components.

Step 2 – Select Cooling Coil (pages 11 to 55)

The cooling coil is selected for chilled water or direct expansion service. Coils are available in 4+, 6+ or 9+ rows, with a nominal fin spacing of 8 or 14 fins per inch. The coil selection is solved with a simple two-step concept – the matching of air side and refrigerant side performance.

Step 3 – Select Heating Coil (pages 56 to 64)

The heating coil is selected for steam or hot water service. Two types of coils are available: return bend for either steam or hot water service, and no freeze for steam service.

Step 4 – Select Humidifier and Accessories (p. 65)

The 39AC Single Zone Dehumidifier accessories include the filter section, face and bypass dampers, mixing box, heating coil sections, bypass ducts, plenum section, and three types of humidifiers: spray, atomizing spray, and steam grid.

Step 5 – Determine Fan Performance (p. 66 to 73)

The fan is part of the basic unit and its size is established when the unit is selected. A low pressure fan is available for all units, while a medium pressure fan is available for the size 7 thru 14 units. The fan motor brake horsepower and fan speeds are determined from the fan performance tables.

The above illustrations show only one of the basic arrangements available. Other arrangements may place the components in different locations.
STEP 1 – SELECT UNIT SIZE

General

It is assumed that prior calculations have already established the dehumidified air quantity required by the proposed system. If the quantity of air required thru the cooling coil has not yet been determined, it may be calculated by methods and factors published in the Carrier System Design Manual or in the ASHRAE Guide. The bypass factor needed for these calculations may be determined for any 39AC unit from the Unit Size and Bypass Factor chart on page 10.

Once the quantity of air required thru the cooling coil is known, unit size and the actual cooling coil face velocity are determined from the chart above or from the table below. In most cases the unit size depends on the cooling coil face velocity desired. This may be specified but, if the choice is left to the system designer, it is recommended that the highest allowable face velocity be used in the interest of economy. The maximum allowable cooling coil face velocity for the 39AC units is 700 fpm. This limit applies regardless of application and therefore, it is possible to accomplish simultaneous dehumidification and reheat with cooling coil face velocities up to 700 fpm.

Since the first step in selecting the unit size is the determination of cooling coil face velocity, all other 39AC components have also been rated in those same terms to reduce the number of required calculations and to facilitate selection.

39AC Unit Selection Example

GIVEN:
1350 cfm
FIND:
39AC Single Zone Weathermaker unit size
Actual cooling coil face velocity

SOLUTION:

Refer to the chart on page 10 entitled Unit Size and Bypass Factor. Enter this chart at 1350 cfm and select a 39AC at 675 fpm coil face velocity.

The bypass factor for the size available coils may be determined by proceeding vertically at the cooling coil face velocity and reading left or right.

The unit selection may also be made by referring to the 39AC cfm capacity table below or physical data table on page 74.

39AC CAPACITY (CFM)

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UNIT SIZE AND BYPASS FACTOR

COIL FACE VELOCITY - FOR DX AND CHILLED WATER COILS (FPM)

With above coils, cooling coil face velocities up to 700 FPM may be used in all units without water carry-over.
### Cooling Coil Selection

#### PHYSICAL DATA - LOW AND MEDIUM PRESSURE UNITS

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#### STEP 2 - SELECT COOLING COIL

**General**

Direct expansion or chilled water cooling coils are offered for each 39AC unit size. The coils are available in 4, 6 and 8 rows, with nominal fin spacing of either 8 or 14 fins per inch. The system designer is not required to evaluate and specify direct expansion coil circuiting because optimum circuiting is predetermined for any coil selection made from this catalog. Chilled water coils, however, offer a choice of either minimum or maximum circuits.

Since the cooling coil constitutes a substantial part of the total cost of an air conditioning unit, the selection of a coil for refrigerant or chilled water service is a matter of economics as well as proper performance. Hence the optimum coil selection is one that assures proper over-all performance and results in the most economical combination of rows and fin spacing.

This catalog permits coil selection to be made from either Grand Total Heat and apparatus dewpoint (effective coil surface temperature) or from entering and leaving air conditions. The selection procedure for either method can be resolved into a very simple two-step concept - the matching of air side and refrigerant side performance.

This concept is the basis of, and has been incorporated in, the cooling coil ratings discussed below.

### Air Side Performance

The first step in cooling coil selection is the evaluation of the coil air side performance. This performance includes the bypass factor and apparatus dewpoint (effective surface temperature) required for a given coil to meet air conditions. Further background is given on page 13.

The coil air side performance may be evaluated by using one of the following methods:

1. **Carrier Air Conditioning Load Estimating Form E-30**
   - When using this form, the coil selection is made by assuming a bypass factor in calculating the air conditioning load. Greater detail on this procedure is given in the Carrier System Design Manual.

2. **Carrier Conversion Charts**
   - By using these charts which appear on pages 14 and 15, a coil can be selected from entering and leaving air conditions.
   - Physically, these are alignment charts which are used to evaluate in a simple manner the psychrometrics or air side performance of the coil.

The air side performance is shown on these conversion charts in terms of coil bypass factor (which depends on the coil row depth and fin spacing) and the apparatus dewpoint required for that condition.

The refrigerant or chilled water side performance of the coil may then be easily determined from the apparatus dewpoint ratings presented in this catalog for both direct expansion and chilled water coils.

### Refrigerant Side Performance

The second step in cooling coil selection is the determination of the refrigerant side performance. This performance includes the refrigerant temperature and chilled water temperature, temperature and pressure drop. The cooling coil ratings used in this catalog represent the refrigerant or chilled water side performance. The direct expansion coil capacity is shown in terms of Grand Total Heat and apparatus dewpoint. The chilled water coil capacity is shown in terms of Grand Total Heat and difference between apparatus dewpoint and entering water temperature.

The cooling coil is tentatively selected from the Carrier Air Conditioning Estimate Form E-40 or the Carrier Conversion Charts, as previously explained, to maintain the same quantitative heat transfer between the refrigerant coil and surface, the apparatus dewpoint for the air side performance is used to determine the refrigerant temperature (or water quantity or temperature) for the coil selected.

If the resulting refrigerant side conditions do not satisfy requirements, it may be necessary to select another coil.
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### FAN SPEEDS AND MOTOR BRAKE HORSEPOWER

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### CHILLED WATER COILS - THE CHILLED WATER SIDEPATH PERFORMANCE FOR THE VARIOUS DIRECT EXPANSION COILS IS PRESENTED IN THE TABLES ON PAGES 17 TO 21 UNDER THE TITLE "DIRECT EXPANSION - APPARATUS DEWPOINT RATINGS." EACH PAGE SHOWS 4x4, 6x6, AND 8x8 ROWS WITH NOMINAL 4x4 AND 14x14 ROWS PER PAGE.

### REFRIGERANT TEMPERATURE IS DETERMINED DIRECTLY FROM TABLES, INCLUDING THE CARRIER THERMODYNAMIC COOLING SYSTEMS.

### THESE RATINGS APPLY TO REFRIGERANTS 12, 22, OR 500.

### DUE TO OPTIMUM COIL CIRCUITING, THE USE OF ANY ONE OF THESE REFRIGERANTS RESULTS IN THE SAME COIL CAPACITY AND REQUIRED REFRIGERANT TEMPERATURES FOR THE SAME UNIT SIZE, COIL DEPTH AND AIR HANDLING UNIT.

### CHILLED WATER COILS - THE CHILLED WATER SIDE-PATH PERFORMANCE FOR THE VARIOUS CHILLED WATER COILS IS SHOWN IN THE CURVES ON PAGES 14 TO 55 UNDER THE TITLE "CHILLED WATER - ADP RATINGS." EACH PAGE SHOWS THE RATING FOR A SINGLE UNIT SIZE FOR EITHER 4x4, 6x6, OR 8x8 ROWS WITH BOTH MAXIMUM AND MINIMUM TEMPERATURES FOR BOTH NOMINAL 8 AND 14 ROWS PER PAGE.

### THE RATING SHOWN ARE LIMITED TO A MAXIMUM WATER RING VELOCITY OF APPROXIMATELY 10 FEET PER SECOND. THE WATER QUANTITY REQUIRED CAN BE DETERMINED EASILY WHEN GRAND TOTAL HEAT ENTERING THE CHILLED WATER SYSTEM AND APPARATUS DEWPOINT ARE KNOWN.

### IF THE COIL BEING SELECTED TO MEET A SPECIFIED WATER QUANTITY AND ENTERING WATER TEMPERATURE, A REVERSED PROCESS CAN BE FOLLOWED IN WHICH THE APPARATUS DEWPOINT (EFFECTIVE SURFACE TEMPERATURE) IS DETERMINED. FOR PROPER COIL SELECTION, THIS APPARATUS DEWPOINT SHOULD CLOSELY APPROACH THE APPARATUS DEWPOINT DETERMINED FROM THE CONVERSION CHART OR FROM THE AIR CONDITIONING LOAD ESTIMATE.

### THE WATER PRESSURE DROP DUE TO THE COIL BEING SELECTED IS ALSO DETERMINED ON EACH PAGE OF COIL RATINGS.

### COOLING COIL SELECTION

### FAN PERFORMANCE

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### CHILLED WATER COILS FOR HEATING SERVICE

### THE CHILLED WATER COIL RATING CAN BE USED WITH HOT WATER FOR WINTER HEATING. WHEN THE CHILLED WATER COILS ARE USED FOR HEATING, THE HOT WATER SUPPLY TEMPERATURE REQUIRED AT WINTER DESIGN MAY BE READILY CHECKED BY MEANS OF THE FORMULAS BELOW:

$$ t_{ew} = GTH + t_{aw} $$

Where:

$$ GTH = \frac{Q}{Q} $$

$$ t_{aw} = t_{aw} - t_{aw} \cdot 0.08 \text{ (F)} $$

$$ t_{aw} = \text{entering water temp to coil (F)} $$

$$ \text{GTH = heating load (Btu/h)} $$

$$ Q = \text{heat transfer index (Btu/hr/F)} $$

$$ t_{aw} = \text{entering dry-bulb temp of air to coil (F)} $$

$$ B = \text{bypass factor} $$

$$ \text{Cf} = \text{cubic ft per minute of air through coil} $$

$$ t_{aw} = \text{effective coil surface temp (F)} $$

### 12

### 13

### 14

### 15

### 16

### 17

### 18

### 19

### 20

### 21
### Cooling Coil Selection

#### FAN SPEEDS AND MOTOR BRAKE HORSEPOWER

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#### COIL PERFORMANCE – SIGNIFICANCE OF APPARATUS DEWPOINT AND BYPASS FACTOR

Decalcifying coils may be selected from either entering and leaving air temperatures or from a fixed coil face and apparatus dewpoint (saturated surface temperature). Specifications of which approach is used, the basic considerations are identical. They can be resolved into a very simple two-step process — the matching of air side and refrigerant side performance.

The air side performance of a cooling coil is relatively independent of the refrigerant (or chilled water) side performance. Air side performance involves the sensible and latent heat transfer between the coil surface and the air, and is represented by the difference between entering and leaving air conditions as the immersion coil coil surface temperature that actually occurs when the coil is in operation.

The refrigerant side performance of the coil involves the same quantitative heat transfer between the coil surface and the refrigerant. The refrigerant side performance is a more important factor in the actual performance of the coil when other factors are considered.

Significantly, the balance point between these two performances is the effective coil surface temperature or apparatus dewpoint, as shown below.

#### SERVICE TEMPERATURE DATING — COILS ARE NOT WATER COOLED COMPONENTS

Let us consider the air side performance. The air leaving a coil is at a temperature that has been reduced by the amount of heat transferred from the air entering the coil to the cold surface. The temperature of the coil surface, and the air leaving the coil are a function of the entering air temperature, the entering air humidity, and the coil efficiency.

The difference between the apparatus dewpoint determined for a coil, for a specified entering and leaving air condition, and the specified minimum refrigerant (or chilled water) temperature coming out of the coil may be considered to be the temperature head at which the refrigerant side of the coil will operate to perform satisfactorily. Therefore, when checking the air side performance of a coil, the apparatus specifications in the data that results in an apparatus dewpoint that is high enough to ensure the desired refrigerant or chilled water side performance.

#### Removable Header Water Coils

Removable header coils are available for minimum circuited flow coils and maximum circuited 4-, 6- and 8-row coils only. To determine the water pressure drop, the normal pressure drop from the curves must be multiplied by 1.25.

In solving for \( \tau_{w} \), the engineer should use the values of \( Q \) and \( BF \) established in the selection of the cooling coil. It is assumed that the water quantity, when using the chilled water coils for winter heating, will be the same as that determined originally for summer cooling.

This percentage varies with the coil flow velocity and the amount and type of internal coil surface turbulence (low depth and fan speed), and is therefore a measure of the air side performance of the coil.
CONVERSION CHART 1

Entering and Leaving Conditions to Apparatus Dewpoint (adp) or Effective Coil Surface Temperature

Apparatus Dewpoint 48 F to 60 F

AIR SIDE SELECTION PROCEDURE

The coil selection method described below can usually be applied very quickly by inspection, after a little experience has been gained. A straight edge held fixed at the entering dry-bulb and oriented in turn to the various intersections of the coil face velocity with the line connecting the entering and leaving wet-bulb quickly indicates the coil which meets the specified leaving dry-bulb.

However, to put in illustration with the chart, the following step-by-step procedure is presented:

1. Draw a line on Chart 1 connecting the entering and leaving wet-bulb temperatures (wet-bulb lines).

2. Select one of the coils. Unless the row depth and/or fin spacing is specified, check the coils in the following order to determine the optimum selection:

   (1) 4-row, 8 fins/inch
   (2) 4-row, 14 fins/inch
   (3) 5-row, 8 fins/inch
   (4) 6-row, 14 fins/inch
   (5) 8-row, 14 fins/inch

3. Use this intersection as a pivot point to determine the leaving dry-bulb. Draw a line (dry-bulb line) from the entering dry-bulb through the pivot point which lies on the leaving dry-bulb and read the leaving dry-bulb. If the leaving dry-bulb is equal to or less than that required, read the adp or the pivot point. If the leaving dry-bulb is above that required, repeat Steps 2 and 3 for another coil.

4. Use the adp determined in Step 3 to check the refrigerant or water side performance of the selected coil. (The direct expansion ratings are on pages 27 to 31. The chilled water ratings are on pages 29 to 55.)

In the event that the refrigerant or water side performance does not satisfy requirements such as load and refrigerant temperature or type and pressure drop, select another coil using the same procedure as described in Steps 2 to 4.

NOTE: Conversion Charts are available in pad form.

LOW PRESSURE

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<tr>
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</tbody>
</table>
## Fan Performance

### Fan Speeds and Motor Brake Horsepower

<table>
<thead>
<tr>
<th>UNIT SIZE</th>
<th>COOLING COIL FACE VELOCITY (FPM)</th>
<th>CAPACITY (CFM)</th>
<th>TOTAL STATIC PRESSURE (IN. W.G.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>8' SPF</td>
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<td>8' SPF</td>
</tr>
<tr>
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<td>1.0</td>
</tr>
<tr>
<td>300 8540</td>
<td>0.4</td>
<td>0.6</td>
<td>1.0</td>
</tr>
<tr>
<td>300 8540</td>
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<td>0.6</td>
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</tr>
<tr>
<td>300 8540</td>
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<tr>
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<td>0.4</td>
<td>0.6</td>
<td>1.0</td>
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</tbody>
</table>

### Low Pressure

Notes for the use of charts:

- Two conversion charts are presented: Chart I covers the range of apparatus developed (Hd) commonly used in central air conditioning. Chart II covers a range of Hd which, although not as common, may exist under special conditions of direct expansion application. As indicated on Chart I, if the point is for a coil in the right of the 45° oblique line, Chart II should be used for the coil.

The charts permit determination of apparatus developed (relative coil surface temperature) and leaving air conditions assumed, allowing use of conventional app. data for both direct expansion and chilled water coils.

---

### CONVERSION CHART 2

#### Entering and Leaving Conditions to Apparatus Dewpoint (adp) or Effective Coil Surface Temperature

- **Application:**
  - **Dewpoint Data:** 36 F to 48 F
  - **Effective Coil Surface Temperature**

#### Example:

**Given:**

- YACM Single Zone, Medium (previously selected)
- 1350 cfm, 87°F cooling coil face velocity

**Entering conditions:**

- 82°F dry-bulb, 67°F wet-bulb

**Leaving conditions:**

- 56.9°F dry-bulb, 55.3°F wet-bulb

**Find:**

- Coil selection and coil

**Solution:**

1. On Conversion Chart No. 1, draw a line from 67.0°F on the entering wet-bulb scale to 56.7°F on the leaving wet-bulb scale (two lines).
2. Select a 4-sm. 8-in. face coil. Enter the chart at coil face velocity of 675 fps for a 4-sm. 8-in. coil and locate the point.
3. The inspection method described in the procedure would indicate the 4-sm, 14 face coil with a bypass factor of 0.18 as the initial selection.
REFRIGERANT SIDE PERFORMANCE

Direct Expansion Cooling Coil Selection Example
(Presuming that air side coil performance has been evaluated)

GIVEN:
39AC4 Single Zone Weathermaker
1350 cfm, 675 fps cooling coil face velocity
GTH = 49,700 Btu/hr
Adp = 53.2°F

Refrigerant temperature

SOLUTION:
The direct expansion apparatus dewpoint ratings for the 39AC4 are on page 17. Enter the ratings for the 4-row, 14 fins/inch coil at an adp of 53.2°F and a GTH of 49,700 Btu/hr with the 39AC4. The refrigerant temperature is 39.3°F (unipointed).

In cases where the refrigerant temperature is 32°F or less, check the table on this page to find the minimum refrigerant temperature for frost prevention.

RECOMMENDED MINIMUM REFRIGERANT TEMPERATURES FOR FROST PREVENTION (F)

<table>
<thead>
<tr>
<th>EWB</th>
<th>300</th>
<th>400</th>
<th>500</th>
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<td>4</td>
<td>6</td>
<td>8</td>
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<td>6</td>
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</tbody>
</table>

NOTES:
1. Coil selection below loadings shown in the rating tables may result in unsatisfactory oil return and refrigerant distribution. Selections at loadings above those shown may result in excessive pressure drops.
2. Selection and operation at refrigerant temperatures below 32°F may result in frost formation. See tables above for minimum recommended refrigerant temperatures at various coil loadings. This warning also applies to any condition where the continuous operation at partial load is required. Under such conditions, the need for a back pressure regulator for compressor capacity control should be investigated.

LOW PRESSURE FAN SPEEDS AND MOTOR BRAKE HORSEPOWER

<table>
<thead>
<tr>
<th>UNIT SIZE</th>
<th>COOLING COIL FACE VELOCITY (FPM)</th>
<th>CAPACITY (CFM)</th>
<th>TOTAL STATIC PRESSURE (IN WC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
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<table>
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<table>
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<table>
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<tr>
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16
### Cooling Coil Ratings

#### FAN SPEEDS AND MOTOR BRAKE HORSEPOWER

<table>
<thead>
<tr>
<th>UNIT SIZE</th>
<th>COIL FACE VELOCITY (CFM)</th>
<th>CAPACITY (CFH)</th>
<th>TOTAL STATIC PRESSURE (IN. WD)</th>
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</thead>
<tbody>
<tr>
<td></td>
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#### LOW PRESSURE

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### DIRECT EXPANSION – APPARATUS DEPOINT RATINGS

<table>
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#### 4 ROWS, 8 FINS/INCH

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#### 4 ROWS, 14 FINS/INCH

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#### 6 ROWS, 8 FINS/INCH

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#### 6 ROWS, 14 FINS/INCH

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#### 8 ROWS, 8 FINS/INCH

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#### 8 ROWS, 14 FINS/INCH

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#### APPARATUS DEPOINT (F)

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#### APPARATUS DEPOINT (F)

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### DIRECT EXPANSION - APPARATUS DEWPOINT RATINGS

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<th>APPARATUS DEWPOINT (F)</th>
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<tr>
<td>6</td>
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<tr>
<td>34</td>
<td>38 42 44 44 46 49 53 54 56 58 60</td>
</tr>
<tr>
<td></td>
<td>34 38 42 44 44 46 49 53 54 56 58 60</td>
</tr>
</tbody>
</table>

#### 6T8 (300 BTU/HR)

#### 4 ROWS, 8 FINS/INCH

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<th>(F)</th>
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<td>34 38 42 44 44 46 49 53 54 56 58 60</td>
</tr>
</tbody>
</table>

#### 4 ROWS, 14 FINS/INCH

<table>
<thead>
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<td>36 38 40 42 44 44 46 49 53 54 56 58 60</td>
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<tr>
<td></td>
<td>34 38 42 44 44 46 49 53 54 56 58 60</td>
</tr>
</tbody>
</table>

#### 6 ROWS, 8 FINS/INCH

<table>
<thead>
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<th>(F)</th>
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<tbody>
<tr>
<td>48</td>
<td>36 38 40 42 44 44 46 49 53 54 56 58 60</td>
</tr>
<tr>
<td></td>
<td>34 38 42 44 44 46 49 53 54 56 58 60</td>
</tr>
</tbody>
</table>

#### 6 ROWS, 14 FINS/INCH

<table>
<thead>
<tr>
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<th>(F)</th>
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</thead>
<tbody>
<tr>
<td>48</td>
<td>36 38 40 42 44 44 46 49 53 54 56 58 60</td>
</tr>
<tr>
<td></td>
<td>34 38 42 44 44 46 49 53 54 56 58 60</td>
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</table>

### APPARATUS RESISTANCE (IN. WG)

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<th>400</th>
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<th>600</th>
<th>600</th>
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<tbody>
<tr>
<td>Cooling</td>
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</tr>
<tr>
<td>Evaporator</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Resist, 14 Fins/Inch</td>
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<td></td>
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<tr>
<td>Low Resist, 14 Fins/Inch</td>
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<tr>
<td>Fan</td>
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<td>Filtering</td>
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<td></td>
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<tr>
<td>Low velocity (3ft/s-1000hp)</td>
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<tr>
<td>High velocity (5ft/s-classic)</td>
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<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

**NOTES:**
1. The wet bulb temperature shown is for a wet coil. To obtain the dry bulb temperature, multiply by 0.72.
2. This table lists all new-coils available. Refer to the steam heating coil capacity tables on pages 63 and 64 for the specific type condensation coil used for each unit size.

### LOW PRESSURE

#### UNIT NPS

<table>
<thead>
<tr>
<th>COOLING COIL, FACE VELOCITY (FCF)</th>
<th>CAPACITY (GPM)</th>
<th>TOTAL STATIC PRESSURE (IN. W.G)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.61</td>
<td>6.75</td>
<td>0.92</td>
</tr>
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<td>0.82</td>
<td>5.08</td>
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</tr>
<tr>
<td>1.00</td>
<td>4.00</td>
<td>1.75</td>
</tr>
<tr>
<td>2.00</td>
<td>2.00</td>
<td>2.00</td>
</tr>
<tr>
<td>2.25</td>
<td>2.25</td>
<td>2.25</td>
</tr>
<tr>
<td>2.50</td>
<td>2.50</td>
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</tr>
<tr>
<td>3.00</td>
<td>3.00</td>
<td>3.00</td>
</tr>
</tbody>
</table>

### FAN SPEEDS AND MOTOR BRAKE HORSEPOWER
**STEP 5 - DETERMINE FAN PERFORMANCE**

**General**

Fans are a part of the basic unit; hence, when a 39AC unit size is selected, the fan size is established. Fan ratings for the eleven fan sizes available appear on pages 67 to 77, entitled Fan Speeds and Motor Brake Horsepower.

System total static pressures are listed in increments of 0.25 in. wg for 39AC4 thru 6 and 0.25 in. wg for 39AC7 thru 14. Ratings are listed for each unit size in increments of 50 fpm cooling coil face velocity in a range from 300 fpm to 700 fpm.

Once a 39AC unit (including coils and accessories) has been properly selected, the fan performance of the selected unit must be accurately determined in order to establish the fan speed and fan motor horsepower required. Such calculations are quickly and easily made from the data presented on the following pages. Low pressure fan ratings are shown for all 39AC size units, while medium pressure ratings are available only for the 39AC7 thru 14 size units.

**Determination of Fan Speed and Fan Motor Horsepower**

**GIVEN:**

39AC4 unit
1300 cfm, 675 cooling coil face velocity
4-row, 14 fpm/ton cooling coil
1-row, 14 fpm/ton nonfreeze heating coil
High velocity filters
1 in. wg total external static pressure (duct, outlet, etc.)

**FIND:**

Fan speed and fan motor brake horsepower.

**SOLUTION:**

1. Find the resistance of the complete air conditioning apparatus, which is the sum of the resistances of the various components as taken from the Apparatus Resistance table and interpolate for a cooling coil face velocity of 675 fpm. The itemized list, with resistance expressed in inches of water, follows:

   - Cooling coil (4-row, 14 fpm/ton) 0.76
   - Heating coil (nonfreeze steam) 1-row, 14 fpm/ton) 0.29
   - Filters (high velocity) 0.13
   - Total apparatus resistance 1.18

2. Total static pressure is the sum of the total apparatus resistance and the external static pressure 1.18 + 0.00 = 2.18.

3. Enter the 39AC4 Low Pressure Fan Performance Rating table on page 67 in the 2.0 and 2.25 total static pressure column. The interpolated fan performance at 1350 cfm and 675 fpm is 1548 rpm and 0.81 bhp.

**Fan Performance Ratings**

The following notes apply to the fan performance ratings found on the next pages:

1. The ratings have been prepared from data resulting from tests of fans in assembled units and based on standard air. Units were tested in accordance with AMCA Bulletin 210.

2. Where no rating is given in the table, the fan speed is beyond the maximum allowable rpm.

3. Maximum motor size for each unit shown in the following table is limited to that required for the maximum brake horsepower at maximum fan speed and air quantity.

**MAXIMUM MOTOR HORSEPOWER**

<table>
<thead>
<tr>
<th>Low Pressure Units</th>
<th>Unit Size</th>
<th>Max Motor Size (1000 rpm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unit Size</td>
<td>Max Motor Size (1000 rpm)</td>
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<tr>
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<td>1.5</td>
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</tr>
<tr>
<td>39AC5</td>
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<td>2</td>
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<tr>
<td>39AC6</td>
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<td>3</td>
</tr>
<tr>
<td>39AC7</td>
<td>7.5</td>
<td>7.5</td>
</tr>
<tr>
<td>39AC8</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>39AC9</td>
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<td>15</td>
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<td>39AC10</td>
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<td>39AC12</td>
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<td>30</td>
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<tr>
<td>39AC13</td>
<td>40</td>
<td>40</td>
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</tbody>
</table>

*Sizes 13 and 14 use floor mounted motors greater than 50 hp.
### DIRECT EXPANSION - APPARATUS DEWPOINT RATINGS

<table>
<thead>
<tr>
<th>APPARATUS DEWPOINT (F)</th>
<th>APPARATUS DEWPOINT (F)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tr>
<tr>
<td><strong>6TH ROWS, 8 PINS/INCH</strong></td>
<td></td>
</tr>
<tr>
<td>132</td>
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<td>152</td>
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### HUMIDIFIER DISCHARGE CAPACITIES (LB/HR)

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*These humidifiers are designed for use with 60 psi 3/4" copper pipe. 10 psi capacity at 25 psi water pressure of 15 psi should be used for 10 psi supply pressure connections.
### STEAM HEATING COIL CAPACITIES (Based on 2 psig Steam, 60 F Entering Air. See Notes, p. 63.)

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### Cooling Coil Ratings

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### DIRECT EXPANSION - APPARATUS DEWPOINT RATINGS

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### APPARATUS DEWPOINT (F)

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### REFRIGERANT TEMP (F)

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### 4 ROWS, 8 FINS/INCH

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### 6 ROWS, 14 FINS/INCH

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Refrigerant Side Performance

Chilled Water Cooling Coil Selection Examples:

(assuming that air side coil performance has been evaluated)

Example 1

Given:

93AC4 Single Zone Weathermaker
1350 cfm, 675 fpm cooling coil face velocity

GTH = 49,700 Btu/hr

42°F entering water temperature

Maximum gpm = 15

Example 2

Minimum pressure drop = 7 ft

Coil = 4-row, 14 fps/ins. Conversion Chart

Find:

Minimum or maximum circuit coil selection, gpm, pressure drop and water temperature rise.

Solution:

The chilled water ratings for the 93AC4 with a 4-row coil are on page 23. Calculate Q2:

\[
Q = \frac{GTH (1000)}{t_{d,p} - t_{w}} = \frac{49.7}{53.2 - 42} = 46.97\quad 4.4
\]

The pressure drop is found from the curve at the top of the rating page:

Max. circuit coil, pressure drop = 6 ft

Min. circuit coil, pressure drop = 17 ft

The maximum circuit coil meets the requirements.

The water temperature rise is found as follows:

\[
Rise = \frac{GTH}{500 \times \text{gpm}} = \frac{49,700}{500 \times 12} = 8.3\quad \text{F}
\]

Example 2

Given:

Same conditions as Example 1, except specified gpm = 12.

Find:

Minimum or maximum circuit coil selection to satisfy air side requirements and pressure drop.

Solution:

Enter the 4-row, 14 fps/ins. capacity ratings on page 23 at gpm = 12 and a coil face velocity of 675 fpm.

For the minimum circuit coil at the specified gpm, the capacity ratings and pressure drop are exceeded and, therefore, this coil cannot be used.

For the maximum circuit coil on the same chart, Q = 4.65.

Pressure drop = 7 ft (acceptable)

Calculate as:

\[
Q = \frac{GTH (1000)}{t_{d,p} - t_{w}} = \frac{49.7}{53.2 - 42} = 46.97\quad 4.4
\]

This tdp is within 1/2 degree of the tdp determined from the air side performance and is acceptable. Thus, the coil can maintain air conditions with the specified gpm and within the pressure drop requirements.

If chilled water coils are to be used also for heating service, see procedure on page 12.

If removable header coils are to be used (maximum circuitted 4-, 6- and 8-row, or minimum circuit-4-row), multiply catalog water pressure drop by 1.25.

Steam Heating Coil Capacities

Based on 2 psig Steam and 60°F Entering Air

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</table>

Notes:

1. Coil face velocity based on cooling coil face area. Actual heating coil face area is smaller. See Physical Data, page 76.

2. Ratings are based on steam pressures of 2 psig to coil of 2 psig. This pressure does not include pressure drop across the valves.

3. Air capacity not to exceed 0.9% of GTH at 70°F and temperatures over 150°F may be available upon request and charge.

Steam BTU Constants

Based on 2 psig Steam and 60°F Entering Air

<table>
<thead>
<tr>
<th>Steam Pressure (psig)</th>
<th>Steam Heats (Btu/hr)</th>
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Capacity correction factors should be applied for conditions other than those shown in tables on pages 63 and 64.

Formulas:

1. Steam coil capacity - Btu output of coil in 2 psig steam pressure and 60°F entering air temp.

2. Final air temp. = entering air temp. - \( \frac{100}{1.05} \times \text{Btu/hr} \)

Capacity correction factors should be applied for conditions other than those shown in tables on pages 63 and 64.
Steam Coil Selection Example

GIVEN:

39AC4 Single Zone Weathermaker
Cooling coil face velocity = 675 fpm
1350 cfm = 350 cfm of 0 F outside air
+ 1000 cfm of 75 F return air
Heating load = 65,000 Btu/hr
5 pound steam available

FIND:

Nonfreeze steam coil selection, capacity, and leaving air temperature.

SOLUTION:

The temperature of the air mixture entering the coil is:

\[
t_{in} = \frac{(\text{outside air cfm} \times \text{outside air temp}) + (\text{return air cfm} \times \text{return air temp})}{\text{total cfm}}
\]

\[
= \frac{(350 \times 0) + (1000 \times 75)}{1350} = 55.5 \text{ F}
\]

The tabular ratings on page 63 show that two nonfreeze steam coils are available for the 39AC4. The rating for the 1-row, 14 fins/inch coil, based on 2 pounds steam and 60 F entering air and interpolated for 675 fpm, is:

Capacity = 68,750 Btu/hr

The rating for this coil with 5 pounds steam and 55.5 F entering air is obtained by multiplying the above capacity by the appropriate steam Btu constant from the table on page 63.

Capacity = 68,750 \times 1.09 = 75,000 Btu/hr

The 1-row, 14 fins/inch coil has the required capacity. The leaving air temperature is:

Leaving temp = entering temp + \frac{\text{Btu/hr}}{\text{cfm} \times 1.08}

= 55.5 + \frac{75,000}{1350 \times 1.08}

= 55.5 + 51.5 = 107.0
39AC5 4-row Chilled Water - ADP Ratings

COOLING CAPACITY 8 FINS/INCH

Q (thousands) = GRAND TOTAL HEAT (BTU/HR) / \( \frac{\Delta P_{\text{in}} \cdot \Delta P_{\text{out}}}{\text{F}} \)

P.G.M THRU COIL

39AC8 Hot Water Coil Ratings

VELOCITIES SHOWN ON ALL CHARTS BELOW ARE BASED ON COOLING COIL FACE SPEED.

39AC9

H EAT TRANSFER INDEX = HEAT LOAD (1000 BTU/HR) / \( \frac{\Delta P_{\text{in}} \cdot \Delta P_{\text{out}}}{\text{F}} \)
STEP 3 - SELECT HEATING COIL

General

Heating coils are available in a variety of capacities for 39AC equipment, for either steam or hot water service. There is a choice of two types: non-freeze for steam service, and return bend for either steam or hot water service.

It is assumed that prior calculations have already established the heating requirements and heating coil entering air temperature for the proposed system. If this is not the case, the system designer can determine both requirements by the methods and factors published in the Carrier System Design Manual or in the ASHRAE Guide.

Heating coil selections are easily made from this catalog because the ratings are direct and simple to use and obviate the necessity for basic data calculations to determine the capacity of a coil. It should be noted that the velocity to be used for selection of the heating coil from the ratings is based upon cooling coil face area and standard air, thus eliminating one step in the selection calculation.

Hot Water Coils

Ratings for 2-row hot water coils appear in curve form on pages 57 to 62. The required water temperatures entering the coil or the quantity in gpm may be determined for a given load and coil entering air dry-bulb temperature by means of a heat transfer index plotted against gpm.

The chilled water coils may also be used for heating service as described on page 12.

Steam Coils

Ratings for 1- or 2-row steam coils appear in the table on pages 63 and 64. They are given in terms of capacity and final air temperature and are based on 2 psig steam supply to the coil and 60°F entering air. The capacities of the coils for other steam pressures and entering air temperatures may be calculated by means of a multiplying factor determined from the table on page 63, entitled Steam Btu Constants.

Heating Coil Selection Example – Hot Water Coil

GIVEN:

39AC4 Single Zone Weathermaker
Cooling coil face velocity = 675 fpm
1350 cfm = 350 cfm at 0°F outside air
+ 1000 cfm at 75°F return air
Heating load = 65,000 Btu/hr
Entering water = 175°F (max flow = 16 gpm)

FIND:

Hot water heating coil selection, gpm and pressure drop.

SOLUTION:

The temperature of the air mixture entering the coil is:

\[ t_{m} = \left( \frac{\text{outside air cfm} \times \text{outside air temp}}{1350} + \frac{\text{return air cfm} \times \text{return air temp}}{1350} \right) \]

\[ t_{m} = \left( \frac{350 \times 0 + 1000 \times 75}{1350} \right) = 55.5^\circ\text{F} \]

The ratings for the 39AC4 hot water coils are on page 57.

To enter the ratings, it is necessary to calculate the heat transfer index

\[ \Delta t_{w} = \frac{1000 \text{ Btu/hr}}{\text{ent water temp} - \text{ent dry-bulb temp}} \]

\[ = \frac{65}{175 - 55.5} = .544 \]

The low rise coil will not handle a heat transfer index of .544. Entering the medium rise coil rating curve at a heat transfer index of .544 and a cooling coil face velocity of 675 fpm, the gpm is 14.

The pressure drop curve shows a .40 ft drop for the medium rise coil with 14 gpm. (Also see note 6, page 63.)
39AC Cooling Coil Ratings

**39AC9 8-row Chilled Water - ADP Ratings**

- **Pressure Drop**
  - **Min. Circuit Coil:**
  - **Max. Circuit Coil:**

- **GPM Thru Coil:**

- **Cooling Capacity:** 8 FINS/INCH

\[ Q \text{ (thousands)} = \frac{\text{Grand Total Heat (BTU/HR)}}{T_{\text{dp}} - T_{\text{ew}} (F)} \]

**39AC11 6-row**

- **Pressure Drop**
  - **Min. Circuit Coil:**
  - **Max. Circuit Coil:**

- **GPM Thru Coil:**

- **Cooling Capacity:** 8 FINS/INCH

\[ Q \text{ (thousands)} = \frac{\text{Grand Total Heat (BTU/HR)}}{T_{\text{dp}} - T_{\text{ew}} (F)} \]

**39AC9 8-row Chilled Water - ADP Ratings**

- **Pressure Drop**
  - **Min. Circuit Coil:**
  - **Max. Circuit Coil:**

- **GPM Thru Coil:**

- **Cooling Capacity:** 14 FINS/INCH

\[ Q \text{ (thousands)} = \frac{\text{Grand Total Heat (BTU/HR)}}{T_{\text{dp}} - T_{\text{ew}} (F)} \]

**39AC11 6-row**

- **Pressure Drop**
  - **Min. Circuit Coil:**
  - **Max. Circuit Coil:**

- **GPM Thru Coil:**

- **Cooling Capacity:** 14 FINS/INCH

\[ Q \text{ (thousands)} = \frac{\text{Grand Total Heat (BTU/HR)}}{T_{\text{dp}} - T_{\text{ew}} (F)} \]
Cooling Coil Ratings

39AC

39AC11 8-row  Chilled Water - ADP Ratings

Q (thousands) = \( \frac{\text{GRAND TOTAL HEAT (BTU/HR)}}{T_{\text{adp}} - T_{\text{ew}} (\text{F})} \)

Chilled Water - ADP Ratings  6-row  39AC9

Q (thousands) = \( \frac{\text{GRAND TOTAL HEAT (BTU/HR)}}{T_{\text{adp}} - T_{\text{ew}} (\text{F})} \)
STEP 3 – SELECT HEATING COIL

General

Heating coils are available in a variety of capacities for 39AC equipment, for either steam or hot water service. There is a choice of two types: non-freeze for steam service, and return bend for either steam or hot water service.

It is assumed that prior calculations have already established the heating requirements and heating coil entering air temperature for the proposed system. If this is not the case, the system designer can determine both requirements by the methods and factors published in the Carrier System Design Manual or in the ASHRAE Guide.

Heating coil selections are easily made from this catalog because the ratings are direct and simple to use and obviate the necessity for basic data calculations to determine a capacity of a coil. It should be noted that the velocity to be used for selection of the heating coil from the ratings is based upon cooling coil face area and on standard air, thus eliminating one step in the selection calculation.

Hot Water Coils

Ratings for 2-row hot water coils appear in curve form on pages 57 to 62. The required water temperatures entering the coil or the quantity in gpm may be determined for a given load and coil entering air dry-bulb temperature by means of a heat transfer index plotted against gpm.

The chilled water coils may also be used for heating service as described on page 12.

Steam Coils

Ratings for 1- or 2-row steam coils appear in the table on pages 63 and 64. They are given in terms of capacity and final air temperature and are based on 2 psig steam supply to the coil and 60 F entering air. The capacities of the coils for other steam pressures and entering air temperatures may be calculated by means of a multiplying factor determined from the table on page 63, entitled Steam Btu Constants.

Heating Coil Selection Example – Hot Water Coil

GIVEN:

39AC4 Single Zone Weathermaker

Cooling coil face velocity = 675 fpm

1250 cfm = 350 cfm of 0 F outside air

+ 1000 cfm of 75 F return air

Heating load = 65,000 Btu/hr

Entering water = 175 F (max flow = 16 gpm)

FIND:

Hot water heating coil selection, gpm and pressure drop.

SOLUTION:

The temperature of the air mixture entering the coil is:

\[ t_m = \frac{(\text{outside air cfm} \times \text{outside air temp}) + (\text{return air cfm} \times \text{return air temp})}{\text{total cfm}} \]

\[ = \frac{(350 \times 0) + (1000 \times 75)}{1350} = 55.5 \text{ F} \]

The ratings for the 39AC4 hot water coils are on page 57.

To enter the ratings, it is necessary to calculate the heat transfer index

\[ \frac{Q}{\text{gpm}} = \frac{Q}{\text{gpm}} \times \frac{1000 \text{ Btu/hr}}{Btu} \]

\[ = \frac{65}{175 - 55.5} = .544 \]

The low rise coil will not handle a heat transfer index of .544. Entering the medium rise coil rating curve at a heat transfer index of .544 and a cooling coil face velocity of 675 fpm, the gpm is 14.

The pressure drop curve shows a .40 ft drop for the medium rise coil with 14 gpm. (Also see note 6, page 63.)
39AC5 4-row  Chilled Water - ADP Ratings

COOLING CAPACITY: 8 FINS/INCH

Q (thousands) = \( \frac{\text{GRAND TOTAL HEAT (Btu/hr)}}{\text{LWP} \times \text{LWP} \text{ (F)}} \)

39AC8  Hot Water Coil Ratings

VELOCITIES SHOWN ON ALL CHARTS BELOW ARE BASED ON COOLING Coil FACE PITCH.

COOLING CAPACITY: 14 FINS/INCH

Q (thousands) = \( \frac{\text{GRAND TOTAL HEAT (Btu/hr)}}{\text{LWP} \times \text{LWP} \text{ (F)}} \)
Steam Coil Selection Example

**GIVEN:**

39AC4 Single Zone Weathermaker
Cooling coil face velocity = 675 fpm
1350 cfm = 350 cfm of 0°F outside air
+ 1000 cfm of 75°F return air
Heating load = 66,000 Btu/hr
5 pound steam available

**FIND:**

Nonfreeze steam coil selection, capacity, and leaving air temperature.

**SOLUTION:**

The temperature of the air mixture entering the coil is:

\[
\frac{t_{in}^{'}}{t_{in}^{''}} = \frac{\text{outside air cfm x outside air temp} + \text{return air cfm x return air temp}}{\text{total cfm}} = \frac{(350 \times 75) + (1000 \times 0)}{1350} = 55.5°F
\]

The tabular ratings on page 63 show that two nonfreeze steam coils are available for the 39AC4. The rating for the 1-row, 14 fins/inch coil, based on 2 pounds steam and 60°F entering air and interpolated for 675 fpm, is:

Capacity = 68,750 Btu/hr

The rating for this coil with 5 pounds steam and 55.5°F entering air is obtained by multiplying the above capacity by the appropriate steam Btu constant from the table on page 63.

Capacity = 68,750 x 1.09 = 75,000 Btu/hr

The 1-row, 14 fins/inch coil has the required capacity. The leaving air temperature is:

Leaving temp = entering temp + \(\frac{\text{Btu/hr}}{\text{cm} \times \text{1.0}8}\)

\[
= 55.5 + \frac{75,000}{1350 \times 1.08} = 55.5 + 51.5 = 107.0°F
\]
The water temperature rise is found as follows:

\[ \text{Rise} = \frac{\text{GTH}}{500} = \frac{49700}{500 	imes 12} = 8.3 \text{ F} \]

Example 2 -

GIVEN:

Same conditions as Example 1, except specified gpm = 12.

FIND:

Minimum or maximum circuit coil selection to satisfy air side requirements and pressure drop.

SOLUTION:

Enter the 4-cow, 14 fins/inch capacity ratings on page 23 at gpm = 13 and a coil face velocity of 675 fpm.

For the minimum circuit coil at the specified gpm, the capacity ratings and pressure drop are exceeded and, therefore, this coil cannot be used.

For the maximum circuit coil on the same chart, Q = 4.65.

Pressure drop = 7 ft (acceptable)

Calculate dwp:

\[ dwp = \frac{\text{GTH (1000')} - 42}{42} = 52.7 \text{ F} \]

This value is within 1/2 degree of the dwp determined from the air side performance and is acceptable. Thus, the coil can maintain air conditions with the specified gpm and within the pressure drop requirements.

If chilled water coils are to be used also for heating service, see procedure on page 12.

If removable header coils are to be used (maximum circulated 4-, 6- and 8-cow, or minimum circuit 8- and 12-cow), multiply catalog water pressure drop by 1.25.

**NOTES:**

1. Circulation velocity based on using coil face area. Actual heating coil face area is smaller. See Physical Data, page 74.

2. Ratings are based on steam pressure at or very close to coil 2. This pressure does not include pressure drop across the valve.

3. As capacity ratio is measured on 59F and 29.5F of mercury, barometric pressure piping plus heating coils.

STEAM HEATING COIL CAPACITIES (Based on 2 psig Steam and 60°F Entering Air)

<table>
<thead>
<tr>
<th>Unit Size</th>
<th>No. of</th>
<th>Flow Rate (GPM)</th>
<th>Heat Capacity (BTU/h)</th>
<th>Temperature (F)</th>
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**STEAM BTU CONSTANTS (Based on 2 psig Steam and 60°F Entering Air)**
### STEAM HEATING COIL CAPACITIES (Based on 2 psig Steam, 60 F Entering Air. See Notes, p. 63.)

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### DIRECT EXPANSION - APPARATUS DEWPOINT REFRIGERANT TEMP (°F)

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<td>84</td>
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### REFRIGERANT TEMP (°F)

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<th>4 ROWS, 8 FINS/INCH</th>
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</thead>
<tbody>
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</table>

### APPARATUS DEWPOINT (F)

<table>
<thead>
<tr>
<th>4 ROWS, 14 FINS/INCH</th>
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<tbody>
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### DIRECT EXPANSION - APPARATUS DEWPOINT RATINGS

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### STEP 4 - SELECT HUMIDIFIER AND ACCESSORIES

#### General

Three types of humidifiers are available on the 39AC Single Zone Weathermaker: spray, atomizing, spraying, and steam grid. Select humidifier according to unit size and desired capacity.

#### Spray Humidifier

The 39AC spray humidifier section consists of a header and spray nozzles with a strainer which may be field installed. This humidifier is available on all sizes except 4, 5 and 6. The sprays operate on city water pressure of 15 psi or more. The humidifier should be installed directly ahead of the chilled water coil to permit drain water to flow to the condensate pan and out the condensate piping.

Spray humidifiers may be applied with copper or aluminum lined coils when soft city water is available. If the water is too contaminated, dissimilar fan and tubing materials may result in a significant reduction of coil life due to corrosion.

When industrial gases such as hydrogen sulfide, sulfur dioxide or carbon dioxide are present in the spray water or in the outside air, use an all copper coil. When face and bypass damper control is used, minimum stops should be provided on the face dampers to insure flow of air thru the sprays. A solenoid valve should be installed, or other suitable precautions taken, to shut off sprays when the fan is not running.

#### Atomizing Spray Humidifier

The atomizing spray assembly is made of a single horizontal pipe placed parallel to the cooling coil. (See dimensional drawings on pages 70 thru 81 for approximate location.) Screwed into the pipe are 1/2 inch brass cone spray nozzles with a spray angle of 30 degrees. Each nozzle has a fine mesh brass strainer. To minimize nozzle clogging, it is recommended that the supply pipe also have a strainer.

#### Steam Grid Humidifier

The steam grid humidifier is constructed of an open or slotted stainless steel pipe (extending the width of the unit) thru which an asbestos wrapped steam pipe is passed. The pan is pitched to facilitate condensate drainage. A condensate trap should be used to prevent "hold-up" of condensate in the pan operating under negative pressure. The minimum "water seal" required for condensate traps depends upon the magnitude of the operating pressures. The steam supply to this humidifier should be side free to prevent the air from being con-}

### HUMIDIFIER DISCHARGE CAPACITIES (LB./HR)

<table>
<thead>
<tr>
<th>Unit Size</th>
<th>Number of Humidifiers</th>
<th>Water Pressure (psi)</th>
<th>Capacity at 25 psi Water Press.</th>
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<td>46</td>
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*Water pressure for sizes 4 thru 50 are .75 - 1.75 PSI. Sizes 51 thru 74 are 1.5 - 2.5 PSI.

**Humidifiers with additional steam pipe and water pressure rates of nozzles shall be 13 psi. Water supply connections are 3/4" NPT.**

---

1. Ratings are based on 10 psi steam (5 psi makeup). Steam connections are 3/4" NPT for sizes 1 thru 10, sizes 11 thru 14, 1-1/2" NPT (120 and 270 Btu/hr) only and 2" NPT (275, 350, 425, 500 HP) for sizes 6 thru 30, 3/4" NPT for sizes 1 thru 4.

---

1. Ratings are based on 10 psi steam (5 psi makeup). Steam connections are 3/4" NPT for sizes 1 thru 10, sizes 11 thru 14, 1-1/2" NPT (120 and 270 Btu/hr) only and 2" NPT (275, 350, 425, 500 HP) for sizes 6 thru 30, 3/4" NPT for sizes 1 thru 4.
STEP 5 - DETERMINE FAN PERFORMANCE

General
Fans are a part of the basic unit; hence, when a 39AC unit size is selected, the fan size is established. Fan ratings for the eleven fan sizes available appear on pages 67 to 73, entitled Fans, Speeds and Motor Brake Horsepower.

System static total pressures are listed in increments of 0.25 in. wg for 39AC4 thru 6 and 0.25 in. wg for 39AC7 thru 14. Ratings are listed for each unit size in increments of 50 cfm cooling coil face velocity in a range from 300 cfm to 700 cfm.

Once a 39AC unit (including coils and accessories) has been properly selected, the fan performance of the selected unit must be accurately determined in order to establish the fan speed and fan motor horsepower required. Such calculations are quickly and easily made from the data presented on the following pages. Low pressure fan ratings are shown for all 39AC unit sizes, while medium pressure ratings are available only for the 39AC7 thru 14 size units.

Determination of Fan Speed and Fan Motor Horsepower

GIVEN:
39AC4 unit
1300 cfm, 675 cooling coil face velocity
4-row, 14 fins/inch cooling coil
1-row, 14 fins/inch nonfreeze heating coil
High velocity filters
1 inch wg total external static pressure (duct, outlet, etc.)

FIND:
Fan speed and fan motor brake horsepower.

SOLUTION:
1. Find the resistance of the complete air conditioning apparatus, which is the sum of the resistances of the various components as taken from the Apparatus Resistance table and interpolate for a cooling coil face velocity of 675 rpm. The itemized list, with resistance expressed in inches of water, follows:

- Cooling coil (4-row, 14 fins/inch) .76
- Heating coil (nonfreeze steam 1-row, 14 fins/inch) .29
- Filters (high velocity) .13
- Total apparatus resistance 1.18

2. Total static pressure is the sum of the total apparatus resistance and the external static pressure = 1.18 + 0.00 = 2.18.

3. Enter the 39AC4 Low Pressure Fan Performance Rating table on page 67 in the 2.0 and 2.25 total static pressure column. The interpolated fan performance at 1300 cfm and 675 fpm is 1548 rpm and 0.81 bhp.

Fan Performance Ratings

The following notes apply to the fan performance ratings found on the next pages:

1. The ratings have been prepared from data resulting from tests of fans in assembled units and based on standard air. Units were tested in accordance with AMCA Bulletin 210.

2. Where no rating is given in the table, the fan speed is beyond the maximum allowable rpm.

3. Maximum motor size for each unit shown in the following table is limited to that required for the maximum brake horsepower at maximum fan speed and air quantity.

MAXIMUM MOTOR HORSEPOWER

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<th>Low Pressure Units</th>
<th>Medium Pressure Units</th>
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*Sizes 13 and 14 use floor mounted motor greater than 50 hp.
### Direct Expansion - Apparatus Dewpoint Ratings

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#### Notes:
1. The wet bulb temperature is shown for a wet coil. To obtain the dry bulb temperature, multiply by 72.
2. This table lists all non-heat-coil systems. Refer to the steam heating coil summary tables on pages 63 and 64 for the specific type for each unit size.

### Apparatus Resistance (in. wg)

<table>
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<th>Resistance (in. wg)</th>
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#### Low Pressure

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<th>Cooling Coil Face Velocity (fps)</th>
<th>Capacity (ton)</th>
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### Fan Speeds and Motor Brake Horsepower

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</table>

### Notes:
1. The wet bulb temperature is shown for a wet coil. To obtain the dry bulb temperature, multiply by 72.
2. This table lists all non-heat-coil systems. Refer to the steam heating coil summary tables on pages 63 and 64 for the specific type for each unit size.

#### Formaldehyde (formaldehyde)

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<thead>
<tr>
<th>Component</th>
<th>Resistance (in. wg)</th>
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<tr>
<td>Cooling</td>
<td>1400</td>
</tr>
</tbody>
</table>

#### Notes:
1. The wet bulb temperature is shown for a wet coil. To obtain the dry bulb temperature, multiply by 72.
2. This table lists all non-heat-coil systems. Refer to the steam heating coil summary tables on pages 63 and 64 for the specific type for each unit size.
<table>
<thead>
<tr>
<th>UNIT SIZE</th>
<th>COOLING COIL FACE FLOW (CFM)</th>
<th>CAPACITY (CFH)</th>
<th>TOTAL STATIC PRESSURE (IN. W.G)</th>
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<th>0.8</th>
<th>1.0</th>
<th>1.2</th>
<th>1.4</th>
<th>1.6</th>
<th>1.8</th>
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<th>2.2</th>
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**Cooling Coil Ratings**

**Fan Performance**

**Direct Expansion - Apparatus Dewpoint Ratings**

**GWP**

| 4 5 |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 6   | 6   | 8   | 8   | 10  | 10  | 12  | 12  | 14  | 14  |

**Refrigerant Temp (°F)**

**4 Rows, 8 Fins/Inch**

<table>
<thead>
<tr>
<th>24</th>
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<th>28</th>
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<th>42</th>
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**4 Rows, 14 Fins/Inch**

| 24  | 26  | 28  | 30  | 32  | 34  | 36  | 38  | 40  | 42  |

**6 Rows, 8 Fins/Inch**

| 24  | 26  | 28  | 30  | 32  | 34  | 36  | 38  | 40  | 42  |

**6 Rows, 14 Fins/Inch**

| 24  | 26  | 28  | 30  | 32  | 34  | 36  | 38  | 40  | 42  |

**8 Rows, 8 Fins/Inch**

| 24  | 26  | 28  | 30  | 32  | 34  | 36  | 38  | 40  | 42  |

**8 Rows, 14 Fins/Inch**

| 24  | 26  | 28  | 30  | 32  | 34  | 36  | 38  | 40  | 42  |

**APPARATUS DEWPOINT (°F)**

**APPARATUS DEWPOINT (°F)**

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**Refrigerant Temp (°F)**

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| 24  | 26  | 28  | 30  | 32  | 34  | 36  | 38  | 40  | 42  |

**APPARATUS DEWPOINT (°F)**

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### RECOMMENDED MINIMUM REFRIGERANT TEMPERATURES FOR FROST PREVENTION (F)

#### Direct Expansion Coils – 8 Pints/Inch

<table>
<thead>
<tr>
<th>EWB</th>
<th>300</th>
<th>400</th>
<th>500</th>
<th>600</th>
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<tr>
<td>65</td>
<td>25</td>
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<td>4</td>
<td>5</td>
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</tr>
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#### Direct Expansion Coils – 14 Pints/Inch

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<td>5</td>
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### NOTES:
1. Coil selection below loadings shown in the rating tables may result in unsatisfactory oil return and refrigerant distribution. Selections at loadings above those shown may result in excessive pressure drops.
2. Selection and operation at refrigerant temperatures below 32°F may result in frost formation. See tables above for minimum recommended refrigerant temperatures at various coil loadings. This warning also applies to any situation where continuous operation at partial load is required. Under such conditions, the need for a back pressure regulator for compressor capacity control should be investigated.
### Fan Performance

<table>
<thead>
<tr>
<th>FAN SPEEDS AND MOTOR BRAKE HORSEPOWER</th>
<th>LOW PRESSURE</th>
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</thead>
<tbody>
<tr>
<td><strong>COOLING COIL FAC. VEL. (FPM)</strong></td>
<td><strong>CAPACITY (CFM)</strong></td>
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<td>in.</td>
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### Conversion Chart 2

#### Entering and Leaving Conditions to Apparatus Dewpoint (gph) or Effective Coil Surface Temperature

### Example:

**Given:**

- YAC4 Single Zone Weatherdata (previously selected)
- 1350 cfm, 87.5 fpm cooling coil face velocity
- Entering conditions: 82 F dry-bulb, 67.7 F wet-bulb
- Leaving conditions: 90 F dry-bulb, 55.3 F wet-bulb

**Find:**

- Cool coil selection and coil
- Solution:

1. On Conversion Chart No. 1, draw a line from 67.0 F on the entering wet-bulb scale to 50.2 F on the leaving wet-bulb scale (two line limit).
2. Select a 4-3/8, 8 ft/inch coil. Enter the chart at a coil face velocity of 675 fpm for a 4-3/8, 8 ft/inch coil and locate the point on the curve.
3. Draw a line from 82 F on the entering dry-bulb scale (the coil point on moisture) at 40.9 ft-inches for 675 fpm and parallel to the horizontal axis.
4. The intersection of the two lines gives the coil selection.

### All-Sensible Cooling Applications

For all-sensible cooling applications in horizontal lines or on a Carrier Psychrometric Chart, it is not necessary to draw the wet-bulb line. Connect the specified entering and leaving dry-bulb temperatures and read the coil size from the intersection of the calculated temperature lines and the horizontal axis.
CONVERSION CHART 1

Entering and Leaving Conditions to Apparatus Dewpoint (adp) or Effective Coil Surface Temperature

Apparatus Dewpoint 48 F to 60 F

AIR SIDE SELECTION PROCEDURE

The coil selection method described below can usually be applied very quickly by inspection, after a little experience has been gained. A straight edge held fixed at the entering-dry-bulb and oriented as in figure the various intersections of the coil heat capacity with the line connecting the entering and leaving wet-bulbs quickly indicates the coil which meets the specified leaving dry-bulb.

3. To determine the leaving dry-bulb, draw a line (dry-bulb line) from the entering dry-bulbs through the point on the leaving dry-bulb scale and read the leaving dry-bulb. If the leaving dry-bulb is equal to or less than that required, read the adp at the point if the leaving dry-bulb is above that required, repeat Steps 2 and 3 for another coil.

4. Use the adp determined in Step 3 to check the refrigerant or water side performance of the selected coil. The direct equipment ratings are on page 24 to 36. The chilled water ratings are on page 25 to 55.

In the event that the refrigerant or water side performance does not satisfy requirements such as load and refrigerant temperature or temperature, select another coil using the same procedure as described in Steps 1 to 4.

NOTE: Conversion Charts are available in pad form.

LOW PRESSURE

FAN SPEEDS AND MOTOR BRAKE HORSEPOWER:

UNIT COOLING CAPACITY COIL FACE VELOCITY PER F.P.H. (F.P.H.) 39AC

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MEDIUM PRESSURE

FAN SPEEDS AND MOTOR BRAKE HORSEPOWER:

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71
## FAN SPEEDS AND MOTOR BRAKE HORSEPOWER

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### COOLING COIL SELECTION

#### COOLING COIL SELECTION — SIGNIFICANCE OF APPARATUS DEWPOINT AND BYPASS FACTOR

Dekalbcooling coils may be selected from either entering or leaving air dehumidifier or directflow Grand Twin Heat and apparel dehumidifier (effective surface temperature). Percentages of which approach is used, the basic considerations are identical. They can be resolved (to a very simple two-step concept) for the matching of air side and refrigerant side performance.

The air side performance of a cooling coil is relatively independent of the condenser (or chiller water) side performance. Air side performance involves sensible and latent heat transfer between the coil surface and the air, and is represented by the difference between entering and leaving air conditions as the apparatus coil surface temperature that actually occurs when the coil is in operation.

#### AIR SIDE PERFORMANCE

- **Sensible Heat Transfer:**
  - Between the coil surface and the air, and is represented by the difference between entering and leaving air conditions as the apparatus coil surface temperature that actually occurs when the coil is in operation.

#### REFRIGERANT SIDE PERFORMANCE

- **Sensible Heat Transfer:**
  - Between the coil surface and the refrigerant, and is represented by the difference between entering and leaving refrigerant conditions as the apparatus coil surface temperature that actually occurs when the coil is in operation.

#### SERVICE TEMPERATURE DIAGRAM — COOLING AIR AND WATER COUPLES (G)

Let us consider the air side performance. The air leaving a coil is in contact with air passing through the coil, which has been subjected to temperature and moisture content. This direct contact with the coil surface and subsequent interaction with each other. This rating method is consistent with the description of side coil performance as represented in the current edition of the ASHRAE Guide.

### Definitions of the two important terms involved in the concept are as follows:

1. **Bypass Factor** (BF): A bypass factor in which every process has passed over the coil is completely unheated, and may be represented as follows:

   
   
   BF = 

   
   

2. **Total Air Flow** (T):

   
   

### In solving for **t_w** the engineer should use the values of **G** and **BF** established in the selection of the cooling coil. It is assumed that the water quantity, when using the chilled water coils for winter heating, will be the same as that determined originally for summer cooling.

### Removable Header Water Coils

Removable header coils are available for maximum circuity flow coils and maximum circuity 6- and 8-tow coils only. To determine the water pressure drop, the normal pressure drop from the curves must be multiplied by 1.25.
Chilled Water Coils — The chilled water side performance for the various chilled water coils is shown in the curves on pages 35 to 55 under the title of Chilled Water — ADP Ratings. Each page of curves presents the ratings for a single unit size for either 4-, 6- or 8-row coils with both maximum and minimum air flow for both nominal 8 and 14 fins per inch. The ratings shown are limited to a maximum water tube velocity of approximately 10 feet per second. The water quantity required can be determined easily when Grand Total Heat, entering chilled water temperature and apparatus dewpoint are known.

If the coil being selected is to meet a specified water quantity and entering water temperature, a reversed procedure must be followed in which the apparatus dewpoint (effective surface temperature) is determined. For proper coil selection, this apparatus dewpoint should closely approach the apparatus dewpoint (within 0.2 degree) determined from the conversion charts or from the air conditioning load estimate.

The water pressure drop thru the coil being selected is also included on each page of coil ratings.

Rating Versatility

The apparatus dewpoint method of selecting coils is ideal because it accommodates selection from either entering and leaving conditions or in conjunction with calculations of the cooling load. In the former case it is a simple matter to determine the coil selection from the Conversion Charts discussed above and to check refrigerator side performance from the appropriate table or curve. In the latter case where the coil is selected on its air velocity and rows of depth in conjunction with the cooling load estimate, the choice is simple and natural because the coils always have an integral number of rows for the surface offered. This choice is based on economic factors that are related to the application and type of load, and are very easily learned.

The necessity for basic data calculations is eliminated, even in the case of chilled water coils. The refrigerant temperature or water quantity to satisfy the load conditions can be determined directly from the ratings. If the selection is being made to meet specifications, and the first selection does not conform to the required refrigerant temperature or water quantity, it is a simple matter to check the refrigerator side performance of another coil from the ratings.

Chilled Water Coils for Heating Service

The chilled water coil ratings can be used with hot water for winter heating. When the chilled water coils are used for heating, the hot water supply temperature required at winter design may be readily checked by means of the formulas below:

where

\[ t_{w} = \frac{GTH}{Q} + t_{w} \]

and

- \( GTH \) = heating load (Btu/hr)
- \( Q \) = heat transfer index (Btu/hr°F)
- \( t_{w} \) = entering water temp to coil (F)
- \( t_{w} \) = effective coil surface temp (F)

The water pressure drop thru the coil being selected is also included on each page of coil ratings.
## Cooling Coil Selection

### PHYSICAL DATA – LOW AND MEDIUM PRESSURE UNITS

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### Selecting Cooling Coil

1. **STEP 2 – SELECT COOLING COIL**

   **General**

   - Direct expansion or chilled water cooling coils are offered for each 39AC unit size. The coils are available in 4, 6, and 8 rows, with nominal fin spacing of either 8 or 14 fins per inch. The system designer is not required to evaluate and specify direct expansion coil circuiting because optimum circuiting is predetermined for any coil selection made from this catalog. Chilled water coils, however, offer a choice of either minimum or maximum circuits.

   - Since the cooling coil constitutes a substantial part of the total cost of an air handling unit, the selection of a coil for refrigerant or chilled water service is a matter of economics as well as proper performance. Hence the optimum coil selection is one that assures proper over-all performance and results in the most economical combination of rows and fin spacing.

   - This catalog permits coil selection to be made from either Grand Total Heat and apparatus dewpoint (effective coil surface temperature) or from entering and leaving air conditions. The selection procedure for either method can be resolved into a very simple two-step concept: the **matching of air side and refrigerant side performance**.

   - This concept is the basis of, and has been incorporated in, the cooling coil ratings discussed below.

### Air Side Performance

- The first step in cooling coil selection is the evaluation of the coil air side performance. This performance includes the bypass factor and apparatus dewpoint (effective surface temperature) required for a given coil to meet air conditions. Further background is given on page 13.

- The coil air side performance may be evaluated by using one or more of the following methods:

### Carrier Air Conditioning Load Estimate Form E-10

When using this form, the coil selection is made by assuming a bypass factor in calculating the air conditioning load. Greater detail on this procedure is given in the Carrier System Design Manual.

### Carrier Conversion Charts

- By using these charts which appear on pages 14 and 15, a coil can be selected from entering and leaving air conditions.

- Physically, these are alignment charts which are used to evaluate in a simple manner the psychrometrics or air side performance of the coil.

### Refrigerant Side Performance

- The second step in cooling coil selection is the determination of the refrigerant side performance. This performance includes the refrigerant temperature and chilled water quantity, temperature, and pressure drop. The cooling coil ratings used in this catalog represent the refrigerant or chilled water side performance.

- The direct expansion coil capacity is shown in terms of Grand Total Heat and apparatus dewpoint. The chilled water coil capacity is shown in terms of Grand Total Heat and difference between apparatus dewpoint and entering water temperature.

- The cooling coil is tentatively selected from the **Carrier Air Conditioning Estimate Form E-10** or the **Carrier Conversion Charts**, as previously explained, to maintain the same quantitative heat transfer between the refrigerant and coil surface, the apparatus dewpoint for the air side performance is used to determine the refrigerant temperature (or water quantity or temperature) for the coil selected.

- If the resulting refrigerant side conditions do not satisfy requirements, it may be necessary to select another coil.
UNIT SIZE AND BYPASS FACTOR

COIL FACE VELOCITY — FOR DK AND CHILLED WATER COILS (FPM)

With above coils, cooling coil face velocities up to 700 FPM may be used in all units without water carry-over.

Connections (in.)

NOTES:
1. Cooling and heating coils can be arranged for either right or left-hand piping connections.
2. Motor and drive are mounted on either top or lower right or left sides of unit.
3. Dimensions shown are approximate. Certified dimensional prints are available on request.
STEP 1 - SELECT UNIT SIZE

General

It is assumed that prior calculations have already established the dehumidified air quantity required by the proposed system. If the quantity of air required thru the cooling coil has not yet been determined, it may be calculated by methods and factors published in theCarrier System Design Manual or in the ASHRAE Guide. The bypass factor needed for these calculations may be determined for any 39AC unit from the Unit Size and Bypass Factor chart on page 10.

Once the quantity of air required thru the cooling coil is known, unit size and the actual cooling coil face velocity are determined from the chart above or from the table below. In most cases the unit size depends on the cooling coil face velocity desired. This may be specified but, if the choice is left to the system designer, it is recommended that the highest allowable face velocity be used in the interest of economy. The maximum allowable cooling coil face velocity for the 39AC units is 700 fpm. This limit applies regardless of application and therefore, it is possible to accomplish simultaneous dehumidification and reheat with cooling coil face velocities up to 700 fpm.

Since the first step in selecting the unit size is the determination of cooling coil face velocity, all other 39AC components have also been rated in these same terms to reduce the number of required calculations and to facilitate selection.

39AC Unit Selection Example

GIVEN:
1350 cfm

FIND:
39AC Single Zone Weathermaker unit size
Actual cooling coil face velocity

SOLUTION:

Refer to the chart on page 10 entitled Unit Size and Bypass Factor. Enter this chart at 1350 cfm and select a 39AC at 675 fpm coil face velocity.

The bypass factor for the six available coils may be determined by proceeding vertically at the cooling coil face velocity and reading right or left.

The unit selection may also be made by referring to the 39AC cfm capacity table below or physical data table on page 74.

39AC CAPACITY (CFM)

<table>
<thead>
<tr>
<th>UNIT SIZE</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooling</td>
<td>2.0</td>
<td>3.0</td>
<td>5.0</td>
<td>8.0</td>
<td>11.0</td>
<td>15.3</td>
<td>20.3</td>
<td>27.0</td>
<td>35.3</td>
<td>45.7</td>
<td>58.2</td>
</tr>
<tr>
<td>Coils &amp;</td>
<td>756</td>
<td>900</td>
<td>1000</td>
<td>1150</td>
<td>1350</td>
<td>1650</td>
<td>1950</td>
<td>2400</td>
<td>2800</td>
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<td>600</td>
<td>750</td>
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<td>1000</td>
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<td>1400</td>
<td>1650</td>
<td>2000</td>
<td>2400</td>
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<td>1200</td>
<td>2000</td>
<td>2400</td>
<td>2800</td>
<td>3300</td>
<td>40750</td>
</tr>
</tbody>
</table>

Note: Above data is approximate. Check dimensional data to ensure complete compatibility.
SELECTION PROCEDURE

Engineering information and detailed selection procedures, charts and ratings are given in the following pages. If any phase of air conditioning is not needed, the step for that phase should be eliminated from the selection procedure.

Select equipment as follows:

Step 1 — Select Unit Size (pages 9 and 10)

A unit is selected from 11 sizes and the total cfm range of 600 – 40,750. This unit size is then used in subsequent steps in selecting the unit components.

Step 2 — Select Cooling Coil (pages 11 to 55)

The cooling coil is selected for chilled water or direct expansion service. Coils are available in 4, 5, or 6 rows, with a nominal fin spacing of 8 or 14 fins per inch. The coil selection is solved with a simple two-step concept — the matching of air side and refrigerant side performance.

Step 3 — Select Heating Coil (pages 56 to 64)

The heating coil is selected for steam or hot water service. Two types of coils are available: return bend for either steam or hot water service, and nonfreeze for steam service.

Step 4 — Select Humidifier and Accessories (p. 65)

The 39AC Single Zone Weathmaker accessory includes the filter section, face and bypass dampers, mixing box, heating coil sections, bypass ducts, pleated section, and three types of humidifiers: spray, atomizing spray, and steam grid.

Step 5 — Determine Fan Performance (p. 66 to 73)

The fan is part of the basic unit and its size is established when the unit is selected. A low pressure fan is available for all units, while a medium pressure fan is available for the size 7 thru 14 units. The fan motor brake horsepower and fan speeds are determined from the fan performance tables.

The above illustrations show only one of the basic arrangements available. Other arrangements may place the components in different locations.
### Vertical Bypass

12. Same arrangement and functions as No. 5, but with face and bypass dampers. Note in this setup an external bypass duct is needed.

13. Same arrangement and functions as No. 8. Here a small sheet metal adapter is required to complete the installation of the bypass.

14. Same arrangement and functions as No. 7. Here a bypass heating coil section is required to provide an inlet for the bypass air.

15. Same arrangement and functions as No. 14, except heating coil position is changed so air will bypass both heating and cooling coils. 39AC24 thru 6 use a long bypass plenum to bypass both coils.

### Sizes and Nominal Capacities

<table>
<thead>
<tr>
<th>Model</th>
<th>Maximum Air Flow (c.f.m.)</th>
<th>Cooling Capacity (Btu/hr) (See Note 1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>39AC</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Notes:
1. All capacities are based on minimum air quantity and the cooling coil at 70°F (21°C) dry bulb temperature and 90°F (32°C) wet bulb temperature. All water coil conditions are 110°F (43°C) supply water temperature and 90°F (32°C) return water temperature. Direct expansion coils are based on 45°F (7°C) evaporating temperature.
2. All capacities are based on the dew point of the house air and the coil surface temperature of the coil. The coil surface temperature is determined by the wet bulb temperature of the house air and the room air temperature.
3. Actual coil capacities should be determined for specific job conditions.
**TYPICAL ARRANGEMENTS OF 39AC COMPONENTS, ACCESSORIES AND DISCHARGES**

**HORIZONTAL**

1. Cooling coil section, fan section, long drip pan. For summer cooling only (DX) or summer cooling and winter heating using chilled or hot water.

2. Preheat coil section, cooling coil section, fan section, short drip pan. Summer cooling, winter heating, each with its own coil.

3. Cooling coil section fitted with cooling and heating coils, fan section, short drip pan. For summer cooling with reheat, winter heating.

4. Accessories such as the combination mixing box and filter section may be used with any 39AC unit.

**VERTICAL**

5. Cooling coil section, fan section, short drip pan. For summer cooling only (DX) or summer cooling and winter heating using chilled or hot water.

6. Preheat coil section, cooling coil section, fan section, short drip pan. Summer cooling, winter heating, each with its own coil.

7. Cooling coil section, reheat coil section, fan section, short drip pan. For summer cooling with reheat, winter heating.

8. High velocity filter section with cleanable filters may be used with either the vertical or horizontal unit.

**HORIZONTAL (BYPASS)**

9. Same arrangement and function as No. 1, but with face and bypass dampers. External bypass duct added to provide this control.

10. Same arrangement and functions as No. 2, but with face and bypass dampers. Duct permits bypass of heating and cooling coils.

11. Same arrangement and functions as No. 3, but with face and bypass dampers. Duct permits bypass of cooling coil, not heating coil.

**NOTE:**

The arrangements shown here by no means exhaust the potential for variation permitted by 39AC equipment. The illustrations presented here and the dimensional drawings on pages 15 thru 81 suggest many other possibilities.

---

**39AC 7 THROUGH 12 HORIZONTAL**

"W" REQD. FOR COIL AND FAN SHAFT REMOVAL, EITHER END.

**SIDE VIEW**

**FRONT VIEW**

---

**39AC 13, 14 HORIZONTAL**

"W" REQD. FOR COIL AND FAN SHAFT REMOVAL, EITHER END.

**SIDE VIEW**

**FRONT VIEW**

---

NOTES:

1. Cooling and heating coils can be arranged for either right or left and piping connections.
2. Note and these can be reversed on either top or front, right or left sides of unit.
3. See Physical Data Table for number of sheet metal or duct work connections.
### Face and Bypass Control

An optional face and bypass damper section has been designed to fit externally to the cooling coil section, so as to avoid unnecessary bulk when this control is not required. In horizontal applications, the face and bypass damper section requires the use of a short external duct section so air can be bypassed over (1) the cooling coil or (2) the preheat and cooling coils. In vertical applications an external duct section is not required (unless c preheat coil section is attached to the cooling coil section) with the face and bypass damper section, as air can be diverted directly into the fan section, once a removable panel is unbolted from the fan section.

When vertical face and bypass control is desired in conjunction with a summer cooling and reheat application, the heating coil section must provide the inlet and space for the bypass air to circulate thru the unit. For this particular application, a supplementary section, called a "bypass heating coil section", is provided. When either vertical or horizontal units are arranged for summer cooling and winter heating, control of both cooling and heating coils may be achieved with the face and bypass damper.

### Sound Control

Any piece of rotating equipment generates sound. Whether this sound is disturbing depends on the particular job requirements and, therefore, any sound control or attenuation must be handled on an individual basis. Duct treatment in the form of sound traps or sound absorbers, and flexible connections on the supply as well as on the return sides of the unit should be considered as required by good design practice.

### Other Accessories

Arrangement of other accessories, such as low or high velocity filter sections and mixing boxes, follows the same building block principle discussed above and is illustrated on the following pages.

### Fan Discharge

The fan sections of 39AC units have been designed so that the air discharge outlet may be located in any one of several positions, either in horizontal or vertical applications. Outlet arrangements are illustrated on pages 73-81.

### Motor Mounting Positions

The fan section has been designed so the motor may be located on either the left or right hand side of the unit, on the front or on top of the fan section. When the external bypass duct is used, the top motor mounting position is not available on all unit sizes and arrangements.
UNIT APPLICATION

All 39AC Single Zone Westermakers may be obtained for either horizontal or vertical installation. In either case, the system designer may choose from a number of different arrangements of components and accessories to meet the specific requirements of his project. He also has a choice of air discharge direction, fan motor location and right or left side coil connections.

This flexibility of arrangement is achieved mainly thru adoption of the building block principle of design. The component and accessory "building blocks" may be fitted together in various ways (page 6 - 7). Dimensional drawings (pages 75 - 81) used in conjunction with the illustrations mentioned above, help establish the space required for the various arrangements. They also show component sizes in case disassembly is required at the job to allow passage thru an opening too small for the unit as shipped.

Horizontal Application — 39AC4 thru 6

The 39AC4 thru 6 units use a cooling coil section so that, when combined with a condensate pan, fan section, plenum section and/or heating coil section, it forms a unit with or without simultaneous dehumidification and reheating up to the maximum of 700 fpm coil face velocity. Pages 75 thru 77 show how the cooling coil section is combined with other unit components such as fan section, heating coil section, plenum, condensate pan and accessories.

Horizontal Application — 39AC7 thru 14

Two different cooling coil sections are available for horizontal installations (page 5). The standard coil section is fitted with tracks to accommodate an optional heating coil. A condensate pan that fits under the coil section only is supplied with this arrangement. Use of the standard coil section with heating coil permits simultaneous dehumidification and reheating up to the maximum 700 fpm coil face velocity.

The short coil section for sizes 7 thru 12 is supplied with a longer condensate pan that fits under both the short cooling coil section and the fan section. This arrangement results in a very compact unit but does not permit simultaneous dehumidification and reheating. However, a heating coil, housed in a preheat coil section, may be added upstream of the cooling coil for winter services.

The system designer may specify either type of cooling coil section, less the coil, in cases where user desires a heating and ventilating system to which cooling may be added easily at a later date.

Vertical Application — 39AC4 thru 6

The 39AC4 thru 6 vertical arrangement uses the cooling coil section, plenum, short condensate pan, and fan section to form the basic unit. A vertical reheat coil section can be used between the fan and cooling coil sections. This permits simultaneous dehumidification and reheating. A preheat coil section is added for heating if required.

Vertical Application — 39AC7 thru 14

The standard cooling coil section must always be used here. In the vertical arrangement the heating coil cannot be located in the standard cooling coil section. It must be housed in one of the heating coil sections. It can be positioned either upstream (as preheat) to the standard cooling coil section or downstream in between the standard cooling coil section and the fan section. The latter arrangement permits simultaneous dehumidification and reheating up to the maximum 700 fpm coil face velocity.

39AC4 THRU 6 HORIZONTAL UNIT
With cooling coil, heating coil and fan section with plenum and condensate pan

39AC4 THRU 6 HORIZONTAL UNIT
With cooling coil and fan section with condensate pan

UNIT DATA

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<th>UNIT SIZE</th>
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</tbody>
</table>
SPECIFICATIONS for the guidance of architects and consulting engineers

The contractor shall furnish and install ____________________________
Carrier Model 39AC ____________ Central Station Weathermaker
- ____________- ____________- ____________- ____________- ____________.
- The casing shall be constructed of heavy gauge mill-galvanized steel sheets which are
- reinforced as required with angles or channels.
- The casing panels shall be removable for easy access
to the interior. Insulation for the fan section,
cooling coil section, and heating coil section shall be
- coated one-inch fire resistant glass wool blanket.
- The condensate drain pan shall be equipped with
- one-half inch sheet of waterproof expanded plastic
- fastened to the pan. The coil connections shall be
- on the right (left) end of the unit when facing the
- entering air side of the unit. The fan drive shall
- be on the right (Left) and of the unit when facing the
- entering air side of the unit. The motor shall be
- mounted on the top (front) of the fan section.

The basic unit shall consist of a fan section, a
- condensate drain pan, cooling coil section, fan
- drive package with variable pitch pulleys and V-
- belts, and universal type adjustable motor base.

In addition, the following accessories shall be supplied
- (select only items required):

1. Motor
2. Heating coil section
3. Bypass heating coil section
4. Mixing box
5. Low velocity filter section
6. High velocity filter section
7. Steam grid humidifier
8. Atomizing spray humidifier
9. Spray humidifier
10. Suspension clips
11. Bypass damper section
12. Plenum section
13. Bypass duct assembly
14. Bypass duct extensions

Fan Section

Fans shall be of the forward-curved blade type,
- statically and dynamically balanced. Shafts
- on the two wheel units shall be of large diameter,
- heavy gauge tubular steel. The ends shall be
- swaged and accurately finished for standard ball bearings.

*It is suggested that all such "fill-in" items be tabulated
when more than one unit is specified.

Shafts for single wheel units shall be solid, full
diameter steel, accurately finished for standard ball bearings.
Bearings shall be factory-lubricated and of the self-aligning type.
The centrifugal fan shall deliver ____________ cfm against a total
static pressure of ____________ inches of water gage
(external static pressure of ____________ inches of water gage).
The fan shall be operated well below critical speed at not more than ____________ rpm by not less than
a ____________ horsepower motor. Units shall be tested
in accordance with AMCA Bulletin 210. Fan section shall be designed for ____________ discharge.

Cooling Coils

The cooling coils shall be constructed of copper tubes
with helically wound fins of aluminum (copper).
- Aluminum fins shall be tightly wound and
- mechanically bonded on a copper tube (copper fins
- to be bonded by a complete solder coating of the
- fins and tube). Coil(s) shall be four (six) (eight)
- rows with nominal fin spacing of eight (fourteen)
- fins per inch. Coils shall be of the cartridge type
- for ease of installation and shall be reversible for
- right or left piping connections. Both the supply
- and return connections shall be located on the
core end.

Direct Expansion Coil
(Used when chilled water is used)

The cooling coil shall be designed for direct expansion
operation, using ____________ refrigerant and
a maximum working pressure of 300 psi. The
Grand Total Heat capacity shall be not less than
3000 Btu/hr when handling ____________ cfm of
air at a saturated refrigerant suction temperature
at the coil outlet of ____________ F, under the following
conditions:

<table>
<thead>
<tr>
<th>Dry-Bulb</th>
<th>Wet-Bulb</th>
</tr>
</thead>
<tbody>
<tr>
<td>At entering coil ____________ F ____________ F</td>
<td></td>
</tr>
<tr>
<td>At leaving coil ____________ F ____________ F</td>
<td></td>
</tr>
</tbody>
</table>

Pressure type liquid distribution shall be used
and coil headers shall have gravity oil drainages.
Piping connections shall be of the solder type.

ENGINEERING FEATURES

39AC Draw-Thru Central Station Weathermakers
for Single Zone Applications are available in 11
sizes. 39AC thru 6 units handle 600-3500 cfm at
up to 3 inch total static pressure. 39AC7 thru 14
units handle 2400-4575 cfm and are available as
a low pressure unit up to 4 inch static pressure or
as a medium pressure unit for static pressures
between 4 and 7 inches.

The following features are illustrated on the oppo-
site page.

1. Removable Casing Panels constructed of heavy
sheet metal, flanged and reinforced as required.
All framing and paneling members of all components
and accessories are protected by galvanized finish.

2. Universal Motor Base furnished for range of motor
sizes. May be mounted on either side of unit, on
top (shown) or front of fan section. Variable pitch
pulleys and V-belts available for wide range of fan
speeds. Belt guard is furnished.

3. Insulation of fan section, cooling coil sections and
all accessories downstream from the cooling coil
consists of coated one-inch glass wool blanket
applied at the factory. No field insulation required.

4. Drain Pan insulation consists of half-inch sheet of
waterproof expanded plastic securely fastened
to the pan.

5. Fan Wheels are forward-curved blade type for unit
compactness, statically and dynamically balanced.
Their maximum rated speed is well below the
critical speed. Fan shaft bearings are the factory-
lubricated, self-aligning ball type.

Arrangements for flexibility in design are featured
with the 39AC Single Zone Weathermaker. Numerous
arrangements are available to suit almost any de-
sign criteria thru the unique building block design
which enables unit sections and accessories to be
fitted together in many different ways. Typical 39AC
arrangements on pages 6 and 7 will help the de-
signer select unit components for his application.

6. Heating Coils are available in non-freeze type for
use with steam or the return bend type for use with
steam or hot water. Tight winding mechanically
bonded aluminum fins or solder coated copper fins
may be specified. All coils are of the cartridge
type for ease of installation and are reversible for
right or left end piping connections. Supply and return
connections are located on the same end.

7. Cooling Coils are constructed of copper tube with
a choice of helically wound aluminum or copper
fins. Selection may be made from 4-, 6- or 8-row
coils, with nominal fin spacings of either 8 or 14
fins per inch. Aluminum fins are tightly wound
and mechanically bonded on the tube; copper fins
are bonded by a complete solder coating of the
fins and tube. The coils are the reversible cartridge
type which slide in or out of the coil section on
tracks. Both direct expansion or chilled water coils
are offered. Removable header type chilled water
and brine coils are also available. Supply, return,
vent and drain connections are located on the
same end.

8. Accessories such as filter sections, face and by-
pass dampers, mixing boxes, separate heating coil
sections and humidifiers, when added to the basic
building block of fan and cooling coil section, give
truly flexible arrangements.
Chilled Water and Brine Coil
(Omit when DX is used)

The cooling coil shall be designed for use with chilled water (brine on the refrigerant with freezing point 5°F) and a maximum working pressure of 300 psig. The Grand Total Heat capacity shall be not less than 28,000 Btu/hr when handling 300 cfm of air at an entering water (brine) temperature to the coil of 5°F under the following conditions:

<table>
<thead>
<tr>
<th>Dry-Bulb</th>
<th>Wet-Bulb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air entering</td>
<td>F</td>
</tr>
<tr>
<td>Air leaving</td>
<td>F</td>
</tr>
</tbody>
</table>

The water (brine) circulation rate shall be 1500 gpm at a maximum pressure drop thru the coil of 100 psig. Connections shall be provided for convenient water drainage and air venting of the coil, and all connections shall be threaded. (Provide a full circuated removable header type coil for the service indicated above for a maximum working pressure of 100 psig.)

2. (Omit when steam coil is used.) The entering water temperature shall be _______F at a circulation rate of _______gpm and a maximum pressure drop thru the coil of _______feet.

Accessories

A _______hp, frame 1750 rpm, _______volt, _______phase, _______cycle electric motor shall be provided to drive the fan.

A heating coil section of galvanized steel shall be provided for the heating coil.

A mixing box of galvanized steel shall be supplied with interconnected, double acting damper blades on two wheel units and single acting damper blades on single wheel units for mixing outside and return air.

A low velocity (high velocity) filter section of heavy gauge galvanized steel shall be supplied. Filters shall be removable from either end of the filter section.

An atomizing spray (steam grid) humidifier shall be provided.

Suspension clips shall be provided for suspending the unit(s).

A bypass damper section of galvanized steel shall be supplied. The damper shall be of the double acting type, balanced, and supported at both ends by nylon sleeve bearings.

A bypass plenum section of galvanized steel shall be supplied.

A bypass duct of galvanized steel shall be supplied.

A bypass heating coil section that will allow air to bypass around the cooling coil or around the cooling coil and heating coil shall be supplied (for vertical units only).

1. (Omit when hot water coil is used.) The coil shall be supplied with _______psig steam.

This catalog contains information for product application only. Refer to the Carrier System Design Manual or consult your nearest Carrier office for general information on design of the complete system.
Carrier Dealers, Distributors, and Field Offices are listed in the Yellow Pages. Their experience is at your service.
# PERFORMANCE AND MECHANICAL SPECIFICATIONS

**EVAPCO® AT COOLING TOWERS**

<table>
<thead>
<tr>
<th>PROJECT:</th>
<th>DIABLO VALLEY COLLEGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>CUSTOMER:</td>
<td>MARKEN MECHANICAL</td>
</tr>
<tr>
<td>ENGINEER:</td>
<td>MARKEN MECHANICAL - CONCORD, CA</td>
</tr>
<tr>
<td>UNIT:</td>
<td>(1) AT 19-56 COOLING TOWER</td>
</tr>
<tr>
<td>CUSTOMER P.O. NO.</td>
<td>302-2302</td>
</tr>
<tr>
<td>EVAPCO SERIAL NO.</td>
<td>W026973</td>
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<tr>
<td>CAPACITY:</td>
<td>353 GPM</td>
</tr>
<tr>
<td>°F IN</td>
<td>90</td>
</tr>
<tr>
<td>°F OUT</td>
<td>80</td>
</tr>
<tr>
<td>°F E.W.B.</td>
<td>70</td>
</tr>
<tr>
<td>FAN MOTOR:</td>
<td>(1) 5 INVERTER DUTY HP</td>
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<tr>
<td>ELEC. SPEC.</td>
<td>208/60/3</td>
</tr>
<tr>
<td>INLET PRESSURE:</td>
<td>1.7 PSIG</td>
</tr>
</tbody>
</table>

**UNIT TYPE**

Factory assembled, induced draft, counterflow cooling tower.

**CONSTRUCTION**

All cold water basin components including vertical supports and air inlet louver frames are constructed of Type 304 Stainless Steel. Heavy gauge mill hot-dip galvanized steel casing. Hot-dip galvanized steel channel and angle supports. All galvanized steel is coated with a minimum of 2.35 ounces of zinc per square foot of area (G-235 designation). During fabrication, all galvanized steel panel edges are coated with a 95% pure zinc-rich compound.

**MAKE-UP FLOAT VALVE ASSEMBLY***

Brass float valve with adjustable plastic float.

**PAN STRAINER***

All type 304 stainless steel construction with large area removable perforated screens.

**ACCESS**

Hinged door in the upper casing for fan drive and water distribution system access. Removable louver panels on all four sides of the unit for pan and sump access. Hinged swing away cover for motor access.

**FANS**

Fans are axial propeller type constructed of aluminum alloy and statically balanced. The fan is installed in a closely fitted cowl with venturi air inlet. Fan screens are galvanized steel mesh and have steel frames bolted to the fan cowl.

**FAN SHAFT**

Solid shaft of ground and polished steel.

**FAN SHAFT BEARINGS**

Heavy-duty, self-aligning ball type bearings with extended lubrication lines to grease fittings on the exterior casing. Bearings are designed for a minimum L-10 life of 75,000 hours.

**FAN MOTOR**

Totally enclosed, inverter duty, ball bearing type electric motor with 1.15 service factor suitable for outdoor service. The motor is mounted externally on the unit with an adjustable motor base and swing away protective cover.

**FAN DRIVE**

The fan drive is a multi-groove, solid back, reinforced neoprene V-belt type with taper lock sheaves designed for 150% of the motor nameplate horsepower. Fan sheave is constructed of aluminum alloy. The motor sheave is external to the unit for dry operation.

**FILL**

Polyvinyl Chloride (PVC) of cross-fluted design. PVC sheets are bonded together for strength and durability. Fill is self-extinguishing for fire resistance, has a flame spread of 5 under A.S.T.M. designation E-84-81a, and is resistant to rot, decay and biological attack.
WATER DISTRIBUTION SYSTEM

Precision molded ABS spray nozzles with large 3/8" x 1" orifice to eliminate clogging. Spray header and branches are schedule 40 Polyvinyl Chloride (PVC) for corrosion resistance with steel connection to attach external piping. Spray header branches are removable and are equipped with threaded end caps.

ELIMINATORS

The eliminators are constructed entirely of Polyvinyl Chloride (PVC) in easily handled sections. Design incorporates three changes in air direction and limits the water carryover to a maximum of 0.001% of the circulating water rate.

LOUVERS

The louvers are constructed from Polyvinyl Chloride (PVC) and are mounted in easily removable frames for access to the pan for maintenance. There are two changes in air direction to prevent splash-out and block direct sunlight.

*OMITTED ON UNITS FOR REMOTE SUMP OPERATION:

- SST WATER TOUCH BASIN
- 8.5 FT. WIDE BELT DRIVE
- AT85SSTB-NS INVERTER DUTY

SPECIAL REMARKS:

- (1) Sloped Aluminum Ladder.

Evapco Serial Number: W026973
COMMERCIAL/INDUSTRIAL HVAC AIR HANDLERS

CAPACITIES

- Heating: 400 - 1,600 MBH
- Cooling - CW: 130 - 511 MBH
- Cooling - DX: 105 - 510 MBH
- Air: 3,300 - 22,000 CFM

INSTALLATION

- Indoor
- Outdoor

FUEL

- Natural Gas
- Propane


Form C-AH
BACKGROUND
Reznor was founded in 1888 to manufacture the “Reznor” reflector heater, which used a luminous flame gas burner developed by George Reznor. This technological breakthrough was an immediate success and hastened the expansion of gas heating in residential and commercial applications. Technological development and innovation have been the hallmark of Reznor products through the years. The development of the forced air gas unit heater, the modular Thermocore® heat exchanger, and the high-efficiency, sealed-draft Venturion® unit heater have kept Reznor products at the forefront of technological advances in commercial and industrial gas heating. As a result of this pioneering role in the heating, makeup air, and ventilating equipment field, the products offered today are the most advanced in engineering design to satisfy a wide variety of applications.

FACILITIES
Reznor heaters were first manufactured and sold in Mercer, Pennsylvania (70 miles north of Pittsburgh) in 1888. Over the years, the company has grown and expanded. Today, with sales worldwide, Reznor products are being manufactured in facilities throughout North America and Europe.

PRODUCT SCOPE
Well-equipped engineering laboratories for both product development and testing can be found at many of the manufacturing sites. All domestic labs are agency approved.

Reznor Products include a complete line of heating, makeup air and ventilating systems, using gas, oil, hot water/steam, or electric heat sources. Reznor heater catalogs are designed to aid the engineer, architect or contractor in specifying the correct equipment for all standard and special applications. Technical data is presented on unit heaters, duct furnaces, infrared heaters, makeup air systems, pre-engineered custom-designed systems, energy recovery units, packaged cooling, and evaporative cooling modules. Consult your local Reznor Sales Representative for further assistance in specifying Reznor Equipment for your specific application.

SERVICES
Product service requirements are handled through contractors and/or distributors, with backup from local representatives and factory-based service team. Replacement parts inventories for both warranty and non-warranty requirements are maintained at service centers throughout the country and at the manufacturing facilities.

For the Reznor Representative in your area call 800-695-1901 or go to our web site www.RezSpec.com.
IMPORTANT: Specifications are subject to change without notice. This guide is intended to provide specifications and technical information only.

This guide is not intended to be an instruction manual. When installing heating and ventilating equipment, you must check and conform to all local and national building codes. Improper installation of heating and ventilating equipment could be dangerous. Consult manufacturer's installation manual for instructions and important warnings.

Additional Air Handlers can be found in the Split System Catalog (form number C-SS). These include Model PXH (indoor) and Model RXH (outdoor/rooftop). Each unit is capable of delivering up to 7,000 cfm. Both units are available with:
- DX coils
- Chilled water coils
- Hot water coils
MODEL SSCBL
EXTENDED CAPACITY, GAS-FIRED,
SEPARATED-COMBUSTION, INDOOR, PACKAGED DUCT FURNACE(S)/BLOWER
COMBINATION FOR COMMERCIAL/INDUSTRIAL USE

Reznor® Model SSCBL is a unified assembly of one, two, or three separated-combustion duct furnaces and a large-capacity Reznor blower cabinet. Sizes are available with heating capacities from 400,000 through 1,200,000 BTUH gas input. The standard packages are heating-only systems, but factory-installed gas and inlet-air control options are available to meet makeup air or combination heating/makeup air specifications. These systems are designed for indoor installation in areas with negative pressure and/or extremely dirty or mildly corrosive atmospheres.

Model SSCBL is available for use with either natural or propane gas, as specified. All units are equipped with required limit and safety controls.

Each of the duct furnaces in these packaged systems are designed to separate combustion air from the air in the heated space. The furnaces are engineered and manufactured in accordance with the ANSI definition of “separate combustion.” While discharging exhaust air, the power venter draws in combustion air from the outside atmosphere. Exclusive outside combustion air prevents dirt, lint, dust or other contaminants in the heated space from entering the combustion zone of the furnace. A specially designed combustion-air inlet/vent terminal assembly is required for each duct furnace in a Model SSCBL packaged system. Each furnace section must have a separate terminal assembly. The specially designed terminal assembly requires only one building penetration per furnace section.

Both the separated-combustion duct furnaces and the packaged system are design-certified by the Canadian Standards Association for installation in the U.S. and Canada.

STANDARD FEATURES

- Orifices for natural gas
- Aluminized steel burners with stainless steel insert
- 208-volt power supply
- 24-volt control transformer
- Redundant single-stage combination gas valve on each furnace (see Note 1)
- Intermittent spark pilot
- Fan and limit safety controls
- Reverse air flow limit
- Fan and limit safety controls
- Pre-wired to terminal blocks
- Power venter
- Twin centrifugal blowers with adjustable belt drive
- Galvalume steel cabinet with interlocking joint construction
- Horizontal discharge air opening with duct flanges
- Curb cap base with hangers for suspension
- Blower cabinet (less optional insulation, filter rack and filters) with horizontal inlet-air opening
- Left side controls (facing air stream)
- 1/2” O.D. BX cable (Chicago code)

NOTE 1: Regulated combination redundant gas valve consists of combination pilot solenoid valve, electric gas valve, pilot filter, pressure regulator, pilot shut-off, and manual shut-off, all in one body. Gas supply pressure must not exceed 0.5 PSI (8 oz. - 14” W.C.). Minimum inlet pressure for natural gas is 5” W.C. Minimum inlet pressure for propane gas is 11” W.C.

NOTE 2: Not certified for residential use.
### OPTIONAL FEATURES - FACTORY INSTALLED

- Unit equipped for propane gas
- E-3 (409) stainless steel heat exchanger
- E-3 (409) stainless steel burners
- E-3 (409) stainless steel drip pan
- Intermittent spark safety pilot with timed lockout
- Individual single-stage gas control on each furnace section
- Two-stage gas control on each furnace section - effective 2 to 6 stage gas control (see Gas Control Option page for more detailed description)
- Electronic modulation 50%-100% turndown or 20%-100% turndown
- Variable frequency drive with open dripproof or totally enclosed motor
- VFD control options
  - Soft start
  - Two speed control
  - DDC signal from remote device
- Makeup air controls/dampers
- 208/1, 230/1, 208/3, 230/3, 460/3, 575/3 supply voltages
- 1 HP through 20 HP open dripproof or totally enclosed motors available (motors meet EISA specifications for efficiency)
- Burner air shutters (required for units equipped for propane gas)
- Firestat(s)
- Freezestat(s)
- Convenience outlet
- 1/2” O.D. BX cable (Chicago code)
- Motor starter (optional with motors having internal overload protection)
- Blower cabinet insulation
- Filter rack with 2” disposable, pleated or permanent filters
- Double wall cabinet construction
- FM, GAP manifold arrangements
- High ambient burner cutoff
- Gas pressure safety switches
- Air flow proving switch
- Right side controls (facing airstream)
- Cooling coil cabinet with DX or chilled water coil, requires special handling - see cooling coil cabinet section
- Extended heat exchanger(s) warranty; five (5) or ten (10) year
- Horizontal or vertical combustion-air inlet/vent terminal assembly (one per furnace section; installation requirement)
- Remote control center
- Disconnect switch - UL Listed
- Single-stage thermostat
- Two-stage thermostat
- Two-stage thermostat
- Electronic 7-day programmable thermostat
- Cooling coil cabinet with DX or chilled water coil
- Evaporative cooling module (see Evaporative Cooling Catalog)

### TECHNICAL DATA

#### SIZE 400 500 600 700 800 1050 1200

<table>
<thead>
<tr>
<th>Heating Input BTUH (kW)</th>
<th>400,000 (117.2)</th>
<th>500,000 (146.6)</th>
<th>600,000 (175.9)</th>
<th>700,000 (205.2)</th>
<th>800,000 (234.5)</th>
<th>1,050,000 (307.8)</th>
<th>1,200,000 (351.7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal Output Capacity BTUH (kW)</td>
<td>320,000 (93.8)</td>
<td>400,000 (117.2)</td>
<td>480,000 (140.7)</td>
<td>560,000 (164.1)</td>
<td>640,000 (187.6)</td>
<td>840,000 (246.2)</td>
<td>960,000 (281.4)</td>
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<tr>
<td>Unit Amps (120V) Less Blower Motor</td>
<td>3.1</td>
<td>3.3</td>
<td>3.3</td>
<td>3.6</td>
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<td>5.9</td>
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<td>Standard Control Amps (24V)</td>
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<td>1.67</td>
<td>1.67</td>
<td>1.67</td>
<td>1.67</td>
</tr>
<tr>
<td>Air Volume CFM (m³/hr)</td>
<td>3,300-14,000 (5,607-23,785)</td>
<td>3,700-12,000 (6,286-20,387)</td>
<td>4,450-12,500 (7,560-21,237)</td>
<td>5,200-13,500 (8,835-22,936)</td>
<td>5,900-13,500 (10,043-22,936)</td>
<td>6,500-13,500 (11,572-22,936)</td>
<td>7,400-13,500 (12,572-22,936)</td>
</tr>
<tr>
<td>Net Weight lbs. (kg)</td>
<td>849 (385)</td>
<td>1,104 (501)</td>
<td>1,104 (501)</td>
<td>1,184 (537)</td>
<td>1,245 (565)</td>
<td>1,476 (670)</td>
<td>1,565 (710)</td>
</tr>
<tr>
<td>Ship Weight lbs. (kg)</td>
<td>1,218 (552)</td>
<td>1,588 (720)</td>
<td>1,588 (720)</td>
<td>1,666 (757)</td>
<td>1,898 (861)</td>
<td>2,148 (974)</td>
<td>2,243 (1017)</td>
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<td>Gas Connection—Natural or Propane</td>
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<td>50’</td>
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<td>30’</td>
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<td></td>
<td>7” Pipe</td>
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<td>2</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

---

*a* In the U.S. ratings are for altitudes to 2,000 feet. Above 2,000 feet derate by orifice change, 4% for each 1,000 feet above sea level. In Canada ratings for altitudes to 2,000 feet. For high altitude units (2,001-4,500 ft.) derate by 10% of maximum input.

*b* Weights shown are for standard packaged furnace(s) and blower.

*c* Sizes shown are for natural gas connections, NOT supply line size.

*d* Minimum vent length is 5 feet. Seven inch pipe requires four field-supplied tapered reducers per furnace section. See Separated Combustion Arrangement Section.
**DIMENSIONS**

+ or - 1/8" (3mm)

---

**MODEL SSCBL (cont’d)**

**DIMENSIONS**

+ or - 1/8" (3mm)

---

**Field Wiring Control Voltage**

- Blower Cabinet
- Airflow
- Furnace

---

**Control Side**

- 56"

---

**Furnace Bottom**

- 6"

---

**CLEARANCE FROM COMBUSTIBLES**

- Furnace Bottom - 6"
- Control Side - 56"
- Top, flue connections, side opposite controls - 6"

---

**Key for FIGURE 2 (Codes A-E):**

- A: Width of Cabinet
- B: Width of Horizontal Air Inlet Opening; Width of Optional Return Air (Bottom) Opening
- C: Width of the Curb Cap
- D: Width of Horizontal Discharge Air Opening
- E: Overall Length of Inside of Curb Cap

---

**Air Opening Descriptions & Dimensions**

- Horizontal Air Inlet: 19-1/2"x 495x B
- Optional Return Air Opening: 19-1/2" x 495x B
- Horizontal Discharge Air Opening: 18x D, 457xD

---

**ACCURATE**

- Dimensions E and H listed here do not apply to a system with a field-attached cooling coil cabinet (Option AU2 or AU3); see NOTE in FIGURE 4.

---

**APPROXIMATE Gas Connection Locations**

<table>
<thead>
<tr>
<th>Size</th>
<th>Location Drawing</th>
<th>Approximate Distance from Inside Curb Cap to BLOWER END of System</th>
</tr>
</thead>
<tbody>
<tr>
<td>400</td>
<td>(1)</td>
<td>7' 5-6&quot; 2.26-2.29</td>
</tr>
<tr>
<td>500, 600, 700, 800</td>
<td>(2)</td>
<td>8' 7-8&quot; 2.62-2.64</td>
</tr>
<tr>
<td>1050</td>
<td>(3)</td>
<td>9' 2-3&quot; 2.79-2.82</td>
</tr>
</tbody>
</table>

---

This connection is at curb cap "height" on the control side of the system.
MODEL RPBL
EXTENDED CAPACITY, POWER-VENTED, GAS FIRED, OUTDOOR, PACKAGED DUCT FURNACE(S) / BLOWER COMBINATION FOR COMMERCIAL/INDUSTRIAL HEATING AND MAKEUP AIR

DESCRIPTION
Reznor® Model Series RPBL is factory-designed assembly of one, two, or three duct furnace(s) and a large-capacity blower cabinet and a variety of control options for heating, makeup air or a combination of these functions. Pre-engineered design allows for single unit installation, provides unified appearance, and saves customer engineering time and assembly costs.

Models are available for outdoor use in heating capacities from 400,000 through 1,200,000 BTUH gas input. Model RPBL systems are available for use with either natural or propane gas, as specified. Each unit is equipped with all required limit safety controls.

Controls and wiring are accessible through lift-away side panels.

Model RPBL systems are completely weather sealed. No additional protective covering is required. Each packaged unit is designed for installation on a full roof curb or field supplied supports.

RPBL units feature an integral power vented system for use where environmental conditions pose a problem for gravity-vented units.

STANDARD FEATURES
- Orifices for natural gas
- Aluminized steel heat exchanger (When inlet air temperature is below 40°F or temperature rise is less than 40°F, optional stainless steel heat exchanger is recommended)
- Aluminized steel burners with stainless steel insert
- 208-volt power supply
- 24-volt control transformer
- Redundant single-stage combination gas valve on each furnace (see Note 1)
- Intermittent spark pilot
- Fan and limit safety controls
- Reverse air flow limit
- Twin centrifugal blowers with adjustable belt drive
- Pre-wired to terminal blocks
- Power venter
- Weatherized, galvalume steel cabinet with interlocking joint construction for outdoor mounting
- Horizontal discharge air opening with duct flanges
- Curb cap base
- Horizontal inlet air opening
- Insulated blower cabinet (less optional filter rack and filters)
- Left side access to burner(s) and controls (facing airstream)
- 1/2” O.D. BX cable (Chicago code)

NOTE 1: Regulated combination redundant gas valve consists of combination pilot solenoid valve, electric gas valve, pilot filter, pressure regulator, pilot shut-off, and manual shut-off, all in one body. Gas supply pressure must not exceed 0.5 PSI (8 oz. - 14” W.C.). Minimum inlet pressure for natural gas is 5” W.C. Minimum inlet pressure for propane gas is 11” W.C.

NOTE 2: Not certified for residential use.
• Unit equipped for propane gas
• E-3 (409) stainless steel heat exchanger
• E-3 (409) stainless steel burners
• E-3 (409) stainless steel drip pan
• Intermittent spark pilot with flame supervision and timed lockout
• Individual single-stage gas control on each furnace section
• Two-stage gas control on each furnace section - effective 2 to 6 stage gas control (see Gas Control Option page for more detailed description)
• Electronic modulation (50-100% turndown) (20-100% turndown, size 400)
• Variable frequency drive with open dripproof or totally enclosed motor
• VFD control options
  ♦ Soft start
  ♦ Two speed control
  ♦ DDC signal from remote device
• Makeup air control/dampers
• 208/1, 230/1, 208/3, 230/3, 460/3, 575/3 alternate supply voltages
• 1 HP through 20 HP open drip-proof or totally enclosed motors available (motors meet EISA specifications for efficiency)
• Burner air shutters (required for units equipped for propane gas)
• Firestat(s)
• Freezestat
• Convenience outlet
• 1/2” O.D. BX cable (Chicago code)
• Motor starter (optional with motors having internal overload protection)
• Filter rack with filters (2” disposable, permanent or pleated)
• Downturn plenum cabinet (insulated)
• Discharge dampers, 2-position, with downturn plenum
• Double wall cabinet construction
• GAP, FM manifold arrangements
• High ambient burner cutoff
• Gas pressure safety switches
• Air flow proving switch
• Right side controls (facing airstream)
• Extended warranty on heat exchanger(s); five (5) or ten (10) years

**OPTIONAL FEATURES - FACTORY INSTALLED**

**OPTIONAL FEATURES - FIELD INSTALLED**

**TECHNICAL DATA**

<table>
<thead>
<tr>
<th>SIZE</th>
<th>400</th>
<th>500</th>
<th>600</th>
<th>700</th>
<th>800</th>
<th>1050</th>
<th>1200</th>
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<tbody>
<tr>
<td>Heating Input BTUH (kW)</td>
<td>400,000 (117.2)</td>
<td>500,000 (146.6)</td>
<td>600,000 (175.9)</td>
<td>700,000 (205.2)</td>
<td>800,000 (234.5)</td>
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<td>960,000 (281.4)</td>
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<tr>
<td>Unit Amps (120V) Less Blower Motor</td>
<td>3.1</td>
<td>3.3</td>
<td>3.3</td>
<td>3.6</td>
<td>4.5</td>
<td>5</td>
<td>5.9</td>
</tr>
<tr>
<td>Standard Control Amps (24V)</td>
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<tr>
<td>Air Volume Range cfm (m³/hr)</td>
<td>3,300 - 14,000 (5,607 - 23,785)</td>
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<td>1,184 (537)</td>
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<td>1,588 (720)</td>
<td>1,588 (720)</td>
<td>1,668 (757)</td>
<td>1,898 (861)</td>
<td>2,148 (974)</td>
<td>2,243 (1,017)</td>
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<td>Gas Connection–Natural</td>
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<td></td>
<td></td>
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</tbody>
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* In the U.S. ratings are for altitudes to 2000 feet. Above 2000 feet derate by orifice change, 4% for each 1000 feet above sea level.
* In Canada ratings are for altitudes to 2000 feet. High altitude units (2001 to 4500 ft.) are derated by 10% of maximum input.
* Weights shown are for packaged furnace and blower. For weights of accessories, see below.
* Gas connection for optional propane is 1/2" for all sizes. Sizes shown are for gas connection to single stage gas valve, NOT gas supply line size.
**MODEL RPBL (cont’d)**

**DIMENSIONS**
 (+ or - 1/8” or 3mm)

**FIELD WIRING CONTROL VOLTAGE**

**BLOWER CABINET**

**OPTIONAL RETURN AIR OPENING**

**FIELD WIRING LINE VOLTAGE**

1. **GAS CONNECTION LOCATIONS** (See Table)

2. **OPTIONAL DOWNTURN PLENUM**

---

**LEFT SIDE VIEW**

- **A** = Width of Cabinet
- **B** = Width of Optional Downturn Plenum Discharge Air Opening
- **C** = Width of Inside of the Curb Cap
- **E** = Width of Standard Horizontal Discharge Air Opening
- **G** = Distance between Optional Return Air Cabinet Opening and Optional Downturn Discharge Air Opening

**Air Openings Dimensions**

- **Standard Horizontal Air Inlet**
  - **Dimensions**: 19 1/2" x B (495mm x B)
- **Optional Return Air Opening**
  - **Dimensions**: 19 1/2" x B (495mm x B)
- **Standard Horizontal Discharge Air Opening**
  - **Dimensions**: 18" x E (457mm x E)
- **Optional Discharge Air Opening (w/Downturn Plenum)**
  - **Dimensions**: 19 1/2" x B (495mm x B)

**Key - RPBL Dimensions:**

<table>
<thead>
<tr>
<th>Size</th>
<th>Drawing Location</th>
<th>Approximate Distance from Inside Curb Cap on Blower End of System</th>
</tr>
</thead>
<tbody>
<tr>
<td>400</td>
<td>ft., in.</td>
<td>(M)</td>
</tr>
<tr>
<td>500, 600, 700, 800, 1050, 1200</td>
<td>ft., in.</td>
<td>(M)</td>
</tr>
</tbody>
</table>

**APPROXIMATE Gas Connection Location**

**CLEARANCE FROM COMBUSTIBLES**

1. **Furnace bottom - 0’’. (When installed on a roof curb on a combustible surface, the roof area enclosed within the curb must be either ventilated, left open, or covered with non-combustible material which has an “R” value of at least 5.0).**

2. **Control Side - 56’’ (1,422mm).**

3. **Top Overhangs - 36’’ (914mm).**

---

**SIZE**

<table>
<thead>
<tr>
<th>No. of Furnace Sections</th>
<th>F</th>
<th>G</th>
</tr>
</thead>
<tbody>
<tr>
<td>400</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 (without downturn)</td>
<td>in.</td>
<td>--</td>
</tr>
<tr>
<td>(mm)</td>
<td>(2.127)</td>
<td>--</td>
</tr>
<tr>
<td>1 (with optional downturn)</td>
<td>in.</td>
<td>60 5/16</td>
</tr>
<tr>
<td>(mm)</td>
<td>(1,532)</td>
<td>--</td>
</tr>
<tr>
<td>500, 600, 700, 800</td>
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<td></td>
</tr>
<tr>
<td>2 (without downturn)</td>
<td>in.</td>
<td>--</td>
</tr>
<tr>
<td>(mm)</td>
<td>(2.788)</td>
<td>--</td>
</tr>
<tr>
<td>2 (with optional downturn)</td>
<td>in.</td>
<td>86 5/16</td>
</tr>
<tr>
<td>(mm)</td>
<td>(2,192)</td>
<td>--</td>
</tr>
<tr>
<td>1050, 1200</td>
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<tr>
<td>3 (without downturn)</td>
<td>in.</td>
<td>--</td>
</tr>
<tr>
<td>(mm)</td>
<td>(3,448)</td>
<td>--</td>
</tr>
<tr>
<td>3 (with optional downturn)</td>
<td>in.</td>
<td>112 5/16</td>
</tr>
<tr>
<td>(mm)</td>
<td>(4,058)</td>
<td>(2,853)</td>
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---

**Weights of options shipped on the furnace:**

<table>
<thead>
<tr>
<th>AQ5</th>
<th>Downturn Plenum Cabinet (w/ Includes additional crate)</th>
<th>lbs. (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>400</td>
<td></td>
<td>271 (123)</td>
</tr>
<tr>
<td>500</td>
<td></td>
<td>229 (104)</td>
</tr>
<tr>
<td>600</td>
<td></td>
<td>253 (115)</td>
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<tr>
<td>700</td>
<td></td>
<td>271 (115)</td>
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<td>800</td>
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<td>253 (115)</td>
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<tr>
<td>1050</td>
<td></td>
<td>271 (123)</td>
</tr>
<tr>
<td>1200</td>
<td></td>
<td>400 (182)</td>
</tr>
</tbody>
</table>

**Weights of options shipped separately for field assembly and installation:**

<table>
<thead>
<tr>
<th>AS2</th>
<th>Outside Air Inlet Hood</th>
<th>lbs. (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>96</td>
<td>87 (40)</td>
<td></td>
</tr>
<tr>
<td>92</td>
<td>92 (42)</td>
<td></td>
</tr>
<tr>
<td>96</td>
<td>96 (44)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CJ1</th>
<th>Roof Curb for Basic Unit</th>
<th>lbs. (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>150</td>
<td>167 (76)</td>
<td></td>
</tr>
<tr>
<td>173</td>
<td>179 (81)</td>
<td></td>
</tr>
<tr>
<td>202</td>
<td>202 (92)</td>
<td></td>
</tr>
<tr>
<td>280</td>
<td>280 (127)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CJ2</th>
<th>Roof Curb for Unit with Downturn Plenum Cabinet</th>
<th>lbs. (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>177</td>
<td>193 (86)</td>
<td></td>
</tr>
<tr>
<td>199</td>
<td>205 (90)</td>
<td></td>
</tr>
<tr>
<td>244</td>
<td>228 (103)</td>
<td></td>
</tr>
<tr>
<td>234</td>
<td>234 (106)</td>
<td></td>
</tr>
</tbody>
</table>

---

Form C-AH Page 7
The Reznor® Model RBL is a packaged air handling unit, consisting of a blower/filter cabinet and twin centrifugal blowers. This unit has been engineered for use with Reznor duct furnaces when design considerations do not permit the use of a Reznor packaged system. The cabinet is weatherized with an integral curb cap base for outdoor installation, but may also be installed indoors. The blower cabinet has a standard horizontal discharge air opening. A bottom discharge air opening is available with the addition of an optional downturn plenum. The blower cabinet has a standard horizontal inlet but is engineered to allow for the standard horizontal and/or an optional bottom air inlet with various optional damper control systems. To obtain the desired CFM, a selection of motor and drive combinations are available.

Optional horsepower/voltage motors are available in open dripproof, totally enclosed, energy efficient and two speed.

The optional filter rack will accommodate either 2” disposable, permanent or pleated filters. Pressure drops for each type of filter are listed on the following pages.

To meet a variety of installation requirements, the Model RBL blower cabinet is available with the addition of downturn plenum and/or an outside air inlet hood or evaporative cooling module. The downturn plenum cabinet is a factory-installed option; the outside air hood and evaporative cooling module are shipped separately for field installation. An optional 16” full roof curb is available for cabinets both with or without a downturn plenum.

### STANDARD FEATURES
- Twin centrifugal blowers
- 1 HP, open dripproof motor
- Permanently lubricated ball bearings (1 - 5 HP)
- Pillow block bearings (7-1/2 - 20 HP)
- Adjustable belt drive
- 115-volt supply voltage
- 24-volt, 40 VA control transformer
- Weatherized, aluminized steel construction (Single wall uninsulated)
- Left side controls (facing airstream)
- Horizontal discharge and inlet air openings
- Curb cap base

### OPTIONAL FEATURES - FACTORY INSTALLED
- 208/3, 230/3, 460/3, 575/3 Volt
- 1 HP through 20 HP open drip-proof or totally enclosed motors available (motors meet EISA specifications for efficiency)
- Motor starter (optional with motors having internal overload protection)
- Variable frequency drive with open dripproof or totally enclosed motor
- VFD control options:
  - Soft start
  - Two speed control
  - DDC signal from remote device
- Downturn plenum
- Discharge damper, 2-position, and downturn plenum
- Makeup air controls and dampers
- Outside air hood
- Filter rack with filters (2” disposable, permanent, or pleated)
- Insulated cabinet
- Double wall insulated cabinet
- Convenience outlet
- Right side controls (facing airstream)

### OPTIONAL FEATURES - FIELD INSTALLED
- Roof curb
- Evaporative cooling module
- Disconnect switch - UL listed
- Fill and drain kit for evaporative cooling module
FILTER DIMENSIONS

<table>
<thead>
<tr>
<th>Option</th>
<th>Description</th>
<th>2’ Filters</th>
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<tbody>
<tr>
<td>AW7</td>
<td>2’ disposable</td>
<td>(4) 12x25, (4) 12x30</td>
</tr>
<tr>
<td>AW9</td>
<td>2’ permanent</td>
<td>(8) 12x16, (4) 12x26</td>
</tr>
<tr>
<td>AW11</td>
<td>2’ pleated</td>
<td>(4) 12x25, (4) 12x32</td>
</tr>
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</table>

SHIPPING WEIGHTS

<table>
<thead>
<tr>
<th>Model Option</th>
<th>Description</th>
<th>Ship Weights</th>
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<tr>
<td>RBL</td>
<td>Blower Cabinet</td>
<td>495 (225)</td>
</tr>
<tr>
<td>AG5</td>
<td>Optional downturn plenum</td>
<td>229 (104)</td>
</tr>
<tr>
<td>AS2</td>
<td>Optional 100% outside air inlet hood - shipped separately (requires field assembly)</td>
<td>96 (44)</td>
</tr>
<tr>
<td>CJ1</td>
<td>Optional roof curb for blower cabinet without downturn - shipped separately (requires field installation)</td>
<td>120 (54)</td>
</tr>
<tr>
<td>CJ2</td>
<td>Optional roof curb for blower cabinet with downturn - shipped separately (requires field installation)</td>
<td>145 (66)</td>
</tr>
</tbody>
</table>
### OPTIONAL FEATURE AVAILABILITY

#### Option Code and Description

**RATING PLATE (Models SSCBL & RPBL only)**

- **STD** - U.S. installation
- **CGA** - Canadian Installation

**POWER**

- **AK2** - 208/1
- **AK3** - 230/1
- **AK5** - 208/3
- **AK6** - 230/3
- **AK7** - 460/3
- **AK8** - 575/3

**HEATING OPTIONS (Applies to Models SSCBL & RPBL)**

- **AAC** - Natural gas
- **AG3** - Aluminized steel
- **AG2** - 490 (E-3) stainless steel heat exchanger
- **AG6** - Stainless steel burner
- **AE2** - Burner air shutters
- **AF1** - Aluminized steel burner bottom drip pan
- **AF2** - Stainless steel burner bottom drip pan
- **CC6** - Concentric adapter vertical vent terminal kit (Model SSCBL only)
- **CW7** - Stainless steel burner bottom drip pan
- **CW2** - Extended five (5) year heat exchanger warranty
- **CW3** - Extended ten (10) year heat exchanger warranty

**HEATING CONTROL & SENSOR OPTIONS (Applies to Models SSCBL & RPBL)**

- **AG1** - Single stage space thermostat gas control
- **AG2** - Two stage space thermostat gas control
- **AG3** - Two stage ductstat control
- **AG4** - Two stage gas control with two stage, unit mounted ductstat
- **AG5** - Three stage gas control with two stage, unit mounted ductstat
- **AG7** - Electronic modulation with room thermostat
- **AG8** - Electronic modulation (2 to 1 turndown ratio)
- **AG9** - Electronic modulation (2 to 1 turndown ratio) with remote temperature selector
- **AG10** - Single stage heating gas control with single stage thermostat
- **AG11** - Two stage gas control with two stage digital thermostat
- **AG15** - Two stage gas control with electronic ductstat with remote temperature selector
- **AG16** - Two stage gas control with single stage valve and electronic ductstat with remote temperature selector
- **AG17** - Two stage gas control with electronic ductstat with remote temperature selector and display module
- **AG18** - Three stage gas control with electronic ductstat with remote temperature selector
- **AG19** - Three stage gas control with electronic ductstat with remote temperature selector and display module
- **AG20** - Three stage gas control with electronic ductstat with remote temperature selector and display module
- **AG21** - Electronic modulation (2 to 1 turndown ratio) with signal conditioner and modulating gas regulator
- **AG39, 41** - Electronic modulation (20%-100% firing rate) with duct probe and remote temperature selector
- **AG40, 42** - Electronic modulation (20%-100% firing rate) with signal conditioner and modulating gas regulator

**AIR INTAKE & DAMPER OPTIONS**

- **AR1** - Horizontal inlet air opening
- **AR4** - Outdoor cabinet with bottom air inlet openings
- **AR6** - 30% outside air inlet hood with manual locking damper (Models RPBL & RBL only)
- **AR7** - 30% outside air inlet hood with motorized locking damper (Model RPBL only)
- **AR8** - 100% outside air damper with motor on/off
- **AR15** - Modulating outside and return air mixing dampers with mixing air temperature control
- **AR17** - Alternating 100% outside or return air with 2 position damper motor
- **AR18** - Modulating 100% outside and return air mixing dampers with remote manual dial (potentiometer)
- **AR23** - 100% outside and return air dampers with modulating motor controlled by pressure null switch (Models SSCBL & RPBL only)
- **AR24** - Both horizontal and bottom inlet air openings
- **AR25** - Modulating 100% outside and return air mixing dampers with DDC control

**COOLING OPTIONS (Models SSCBL & RPBL only)**

- **AU2** - Cabinet for chilled water coils (cabinet only, no coils)
- **AU3** - Cabinet for DX cooling coils (cabinet only, no coils)
- **AU11** - Cabinet for chilled water cooling coils and downturn plenum (cabinet only, no coils) (Model RPBL only)
- **AU12** - Cabinet for chilled water cooling coils and downturn plenum with 2 position discharge dampers (cabinet only, no coils) (Model RPBL only)
- **AU13** - Cabinet for DX cooling coils and downturn plenum (cabinet only, no coils) (Model RPBL only)
- **AU14** - Cabinet for DX cooling coils and downturn plenum with 2 position discharge dampers (cabinet only, no coils) (Model RPBL only)
- **AU1A** - Galvanized casing for cooling coils
- **AU1B** - Stainless steel casing for cooling coil
- **AU1C** - ElectroFin™ coating for cooling coil
- **AU2D** - Turbo spiral chilled water coil configuration
- **AU2E** - R410A hot gas bypass ports (Model RPBL only)
- **AU2F** - Single DX coil circuit
- **AU2G** - Dual DX coil circuit (50-50 split)
- **AU3H** - 1/3 - 2/3 DX coil split circuit
- **AU3I** - Copper tubing with aluminum fins coil material
- **AU3J** - Copper tubing with copper fins coil material
- **AU3K** - Turbo spiral chilled water coil configuration
- **AU3L** - Chilled water cooling coils
- **AU3M** - DX cooling coils
- **T4** - Thermal expansion valves (Model RPBL only)
OPTIONAL FEATURE AVAILABILITY (cont’d)

Option Code and Description

OTHER OPTIONS
BC2 - 115V ground fault duplex convenience outlet (Model RPBL only)
BG__ - Various relays
CJ__ - Roof curb options (Models RPBL & RBL only)
CN__ - Remote switches (in lieu of remote console)
CL__ - Thermostats (Models SSCBL & RPBL only)
SA1 - Smoke detector (Models SSCBL & RPBL only)
CP__ - Disconnect switches from 30 amp to 100 amp for use in the U.S. or Canada
RC__ - Remote consoles (Models SSCBL & RPBL only)

SUPPLY & DISCHARGE AIR OPTIONS (Model RPBL & RBL only)
AQ1 - Horizontal discharge opening
AQ5 - Downturn plenum cabinet
AQ8 - Downturn plenum cabinet with 2 position discharge dampers

RPM/BHP Data
Applies to Model RBL

AIR FLOW PRESSURE DROPPS (A.W.C.)

ACCESSORY AND EXTERNAL SYSTEM PRESSURE DROP (A.W.C.)

BLOWER DATA

Form C-AH  Page 11
## BLOWER DATA (cont’d)

### ACCESSORY AND EXTERNAL SYSTEM PRESSURE DROP (*W.C.*)

<table>
<thead>
<tr>
<th>Size</th>
<th>CFM</th>
<th>2&quot;</th>
<th>2&quot;</th>
<th>Pressure Drop with Disposable Filters</th>
<th>Pressure Drop with Permanent Alum. Filters</th>
<th>Pressure Drop with Filtered Filters</th>
<th>Pressure Drop with Evaporative Cooler</th>
<th>Pressure Drop with O/A Hood</th>
<th>Pressure Drop with Dampers</th>
<th>Pressure Drop with Downturn Plenum</th>
<th>External Pressure Drop (Distribution Duct System)</th>
<th>Heating</th>
<th>Cooling</th>
</tr>
</thead>
<tbody>
<tr>
<td>3,300</td>
<td>0.02</td>
<td>0.03</td>
<td>0.03</td>
<td>0.02</td>
<td>0.03</td>
<td>0.02</td>
<td>0.013</td>
<td>0.06</td>
<td>0.01</td>
<td>0.02</td>
<td>N/A</td>
<td>1.22</td>
<td>0.14</td>
</tr>
<tr>
<td>4,000</td>
<td>0.03</td>
<td>0.05</td>
<td>0.06</td>
<td>0.10</td>
<td>0.07</td>
<td>0.08</td>
<td>0.037</td>
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<td>0.04</td>
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<td>0.19</td>
<td>0.19</td>
<td>0.25</td>
<td>0.095</td>
<td>0.40</td>
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<td>0.13</td>
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<td>0.20</td>
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<td>0.23</td>
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<td>0.18</td>
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Notes:
- Filter pressure drop is given for clean filters.
- See cooling coil product submittals.
<table>
<thead>
<tr>
<th>Rise</th>
<th>CFM</th>
<th>0.2</th>
<th>0.4</th>
<th>0.6</th>
<th>0.8</th>
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<th>1.4</th>
<th>1.6</th>
<th>1.8</th>
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<tbody>
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<td>90</td>
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<td>420.4</td>
<td>530.55</td>
<td>600.7</td>
<td>720.1/2</td>
<td>810.1/3</td>
<td>880.1/5</td>
<td>940.1/8</td>
<td>1000/2</td>
<td>1040/2.2</td>
<td>1090/2.7</td>
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<td>1190/3.1</td>
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<td>770/1.25</td>
<td>820/1.4</td>
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<td>1120/2.8</td>
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<td>1060/2.7</td>
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<td>1190/3.3</td>
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<tr>
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<td>500</td>
<td>5400</td>
<td>540/1.0</td>
<td>610/1.25</td>
<td>700/1.5</td>
<td>800/2.8</td>
<td>880/2.2</td>
<td>950/2.6</td>
<td>1000/3.0</td>
<td>1050/3.3</td>
<td>1100/3.5</td>
<td>1140/3.8</td>
<td>1190/4.0</td>
<td>1240/4.3</td>
<td>1250/4.7</td>
<td>1300/4.8</td>
</tr>
<tr>
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<td>780/2.2</td>
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<td>900/3.5</td>
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</tr>
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<td>215/13.1</td>
<td>220/13.6</td>
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---

**Total Adjusted Pressure Drop (W. C.C.) from Air Flow Pressure Drop Table**

**RPM/BHP Chart**

**Applies to Models RBPL & SSCLB**

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**REZNOR**

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**Form C-AH Page 13**
SIZING GAS SUPPLY LINES

Page Number _______ of ______

CAPACITY OF PIPING - NATURAL GAS
Cubic Feet/Meters per Hour Based on 0.3” W.C. Pressure Drop
Specific Gravity for Natural Gas - 0.6 (1,000 BTU/CU Foot)
Diameter of Pipe
Length of Pipe
1/2”
3/4”
1”
1-1/4”
1-1/2”
2”
2-1/2”
Ft
20
Ft3/Hr
92
190
350
730
1100
2100
3300
(M)
(6.1)
(M3/Hr)
(2.6)
(5.4)
(9.9)
(20.7)
(31.1)
(59.5)
(93.4)
Ft
30
Ft3/Hr
73
152
285
590
890
1650
2700
(M)
(9.1)
(M3/Hr)
(2.1)
(4.3)
(8.1)
(16.7)
(25.2)
(46.7)
(76.5)
Ft
40
Ft3/Hr
63
130
245
500
760
1450
2300
(M)
(12.2)
(M3/Hr)
(1.8)
(3.7)
(6.9)
(14.2)
(21.5)
(41.1)
(65.1)
Ft
50
Ft3/Hr
56
115
215
440
670
1270
2000
(M)
(15.2)
(M3/Hr)
(1.6)
(3.3)
(6.1)
(12.5)
(19.0)
(36.0)
(56.6)
Ft
60
Ft3/Hr
50
105
195
400
610
1105
1850
(M)
(18.3)
(M3/Hr)
(1.4)
(3.0)
(5.5)
(11.3)
(17.3)
(31.3)
(52.4)
Ft
70
Ft3/Hr
46
96
180
370
560
1050
1700
(M)
(21.3)
(M3/Hr)
(1.3)
(2.7)
(5.1)
(10.5)
(15.9)
(29.7)
(48.1)
Ft
80
Ft3/Hr
43
90
170
350
530
990
1600
(M)
(24.4)
(M3/Hr)
(1.2)
(2.5)
(4.8)
(9.9)
(15.0)
(28.0)
(45.3)
Ft
90
Ft3/Hr
40
84
160
320
490
930
1500
(M)
(27.4)
(M3/Hr)
(1.1)
(2.4)
(4.5)
(9.1)
(13.9)
(26.3)
(42.5)
Ft
100
Ft3/Hr
38
79
150
305
460
870
1400
(M)
(30.5)
(M3/Hr)
(1.1)
(2.2)
(4.2)
(8.6)
(13.0)
(24.6)
(39.6)
Ft
125
Ft3/Hr
34
72
130
275
410
780
1250
(M)
(38.1)
(M3/Hr)
(1.0)
(2.0)
(3.7)
(7.8)
(11.6)
(22.1)
(35.4)
Ft
150
Ft3/Hr
31
64
120
250
380
710
1130
(M)
(45.7)
(M3/Hr)
(0.9)
(1.8)
(3.4)
(7.1)
(10.8)
(20.1)
(32.0)
Ft
175
Ft3/Hr
28
59
110
225
350
650
1050
(M)
(53.3)
(M3/Hr)
(0.8)
(1.7)
(3.1)
(6.4)
(9.9)
(18.4)
(29.7)
Ft
200
Ft3/Hr
26
55
100
210
320
610
980
(M)
(61.0)
(M3/Hr)
(0.7)
(1.6)
(2.8)
(5.9)
(9.1)
(17.3)
(27.8)
NOTE: When sizing supply lines, consider possibilities of future expansion and increased heating
requirements. Refer to National Fuel Gas Code for additional information on sizing supply line.
CAPACITY OF PIPING - PROPANE
Cubic Feet/Meters per Hour Based on 0.3” W.C. Pressure Drop
Specific Gravity for Propane Gas - 1.6 (2,550 BTU/CU Foot)
Diameter of Pipe
Length of Pipe
1/2”
3/4”
1”
1-1/4”
1-1/2”
2”
2-1/2”
Ft
20
Ft3/Hr
56
116
214
445
671
1281
2013
(M)
(6.1)
(M3/Hr)
(1.6)
(3.3)
(6.1)
(12.6)
(19.0)
(36.3)
(57.0)
Ft
30
Ft3/Hr
45
93
174
360
543
1007
1647
(M)
(9.1)
(M3/Hr)
(1.3)
(2.6)
(4.9)
(10.2)
(15.4)
(28.5)
(46.6)
Ft
40
Ft3/Hr
38
79
149
305
464
885
1403
(M)
(12.2)
(M3/Hr)
(1.1)
(2.2)
(4.2)
(8.6)
(13.1)
(25.1)
(39.7)
Ft
50
Ft3/Hr
34
70
131
268
409
775
1220
(M)
(15.2)
(M3/Hr)
(1.0)
(2.0)
(3.7)
(7.6)
(11.6)
(21.9)
(34.5)
Ft
60
Ft3/Hr
31
64
119
244
372
674
1129
(M)
(18.3)
(M3/Hr)
(0.9)
(1.8)
(3.4)
(6.9)
(10.5)
(19.1)
(32.0)
Ft
70
Ft3/Hr
28
59
110
226
342
641
1037
(M)
(21.3)
(M3/Hr)
(0.8)
(1.7)
(3.1)
(6.4)
(9.7)
(18.2)
(29.4)
Ft
80
Ft3/Hr
26
55
104
214
323
604
976
(M)
(24.4)
(M3/Hr)
(0.7)
(1.6)
(2.9)
(6.1)
(9.1)
(17.1)
(27.6)
Ft
90
Ft3/Hr
24
51
98
195
299
567
915
(M)
(27.4)
(M3/Hr)
(0.7)
(1.4)
(2.8)
(5.5)
(8.5)
(16.1)
(25.9)
Ft
100
Ft3/Hr
23
48
92
186
281
531
854
(M)
(30.5)
(M3/Hr)
(0.7)
(1.4)
(2.6)
(5.3)
(8.0)
(15.0)
(24.2)
Ft
125
Ft3/Hr
21
44
79
168
250
476
763
(M)
(38.1)
(M3/Hr)
(0.6)
(1.2)
(2.2)
(4.8)
(7.1)
(13.5)
(21.6)
Ft
150
Ft3/Hr
19
39
73
153
232
433
689
(M)
(45.7)
(M3/Hr)
(0.5)
(1.1)
(2.1)
(4.3)
(6.6)
(12.3)
(19.5)
Ft
175
Ft3/Hr
17
36
67
137
214
397
641
(M)
(53.3)
(M3/Hr)
(0.5)
(1.0)
(1.9)
(3.9)
(6.1)
(11.2)
(18.2)
Ft
200
Ft3/Hr
16
34
61
128
195
372
598
(M)
(61.0)
(M3/Hr)
(0.5)
(1.0)
(1.7)
(3.6)
(5.5)
(10.5)
(16.9)
NOTE: When sizing supply lines, consider possibilities of future expansion and increased heating
requirements. Refer to National Fuel Gas Code for additional information on sizing supply line.

Form C-AH Page 14


## CONTROL OPTIONS

### Heating Control Options

#### IGNITION CONTROL OPTIONS

**STANDARD EQUIPMENT**  
INTERMITTENT SPARK PILOT: Automatic lighting of pilot with an electronic spark on a call for heat. Pilot gas flow is shut off between heat cycles. Certified by the Canadian Standards Association for use in Canada with natural gas only. Certified for use in the U.S.A. on outdoor units with natural gas or propane.

**OPTION AH3 INTERMITTENT SPARK PILOT WITH LOCKOUT:** Automatic lighting of pilot with an electronic spark on a call for heat. Pilot gas flow is shut off between heat cycles. This system also incorporates a lockout device which stops gas flow to the pilot if the pilot fails to light in 120 seconds. The lockout will automatically be reset after one hour, or it can be manually reset by interrupting the thermostat circuit. Approved for use with natural or propane gas.

### GAS CONTROL OPTIONS

**Option AG1 ONE-STAGE CONTROL:** Single-stage gas valve which cycles on at 100% fire on a call for heat by a remote single-stage thermostat. Thermostat is not included.

**Option AG10 ONE-STAGE CONTROL** for units with one, two or three furnace sections: Each furnace is equipped with single-stage gas valve and relay. Each furnace cycles on at 100% fire on call for heat from remote single-stage thermostat. Thermostat is included.

**Option AG2 TWO-STAGE CONTROL:** Two-stage gas valve which fires at 100% or 50%, as required, on call by a remote two-stage thermostat. Thermostat is not included.

**Option AG11 TWO-STAGE HEATING CONTROL** for units with one, two or three furnaces: Each furnace is equipped with a two-stage gas valve and relay. Two-stage gas valves fire at 100% or 50% as required, on call from remote two-stage thermostat. Thermostat is included.

**Option AG7 ELECTRONIC MODULATION (60°-85°F):** Solid state control system, providing close temperature control via manifold pressure. On a call for heat from a remote electronic thermostat, controls modulate between 50% and 100%. Remote thermostat is included.

**Option AG3 TWO-STAGE CONTROL FROM DUCTSTAT (60°-110°F):** Two-stage gas valve which fires at 100% or 50% as required, on call from a unit-mounted, two-stage ductstat. For units with two furnace sections, Option AG3 includes a two-stage valve on each furnace and two ductstats which provide for FOUR-STAGE CONTROL. For units with three furnace sections, Option AG3 includes a two-stage valve on each furnace and three ductstats which provide for SIX-STAGE CONTROL.

**Option AG15 ELECTRONIC TWO-STAGE CONTROL USING DUCTSTAT (50°-130°F) WITH REMOTE TEMPERATURE ADJUSTMENT:** Same type of control as Option AG3, but the setpoint of the ductstat is adjustable from a remote temperature-selector. Includes factory-installed sensor and field-installed temperature-selector module with an adjustable stage-adder module. For Model RPBL packages with two furnace sections, Option AG15 includes a two-stage valve on each furnace and ductstat which provides for FOUR-STAGE CONTROL. For units with three furnace sections, Option AG15 includes a two-stage valve on each furnace and ductstat which provides for SIX-STAGE CONTROL.

**Option AG4 TWO-STAGE CONTROL FOR UNITS WITH TWO (2) FURNACES:** Each furnace is equipped with a single-stage gas valve. The gas valves are staged by a unit-mounted, two-stage ductstat (60°-110°F). The furnace nearest the blower is staged first and the downstream furnace is staged second. Applicable only to packaged systems with two furnace sections.

---

**APPLICATION NOTE:** If the installation of a packaged unit with more than one furnace section requires that any of the controls in this table be used in conjunction with an override thermostat, additional factory-installed relays are required. Since this application is not covered by “normal” control sequence, the additional relays (Option BG2) must be specified.
CONTROL OPTIONS (cont’d)

Option AG17 ELECTRONIC TWO-STAGE CONTROL FOR RPBL WITH TWO (2) FURNACE SECTIONS USING A DUCTSTAT (50°-130°F) WITH REMOTE TEMPERATURE ADJUSTMENT: Same type of control as Option AG4, but the ductstat has a remote temperature selector. Includes factory-installed sensor and field-installed remote temperature-selector module with an adjustable stage-adder module.*

Option AG18 ELECTRONIC TWO-STAGE CONTROL FOR UNITS WITH TWO (2) FURNACE SECTIONS USING A DUCTSTAT (50°-130°F) WITH REMOTE TEMPERATURE ADJUSTMENT AND TEMPERATURE DISPLAY: Same as Option AG17, plus a digital (liquid crystal) temperature-display module that provides selectable set point display and continuous display of sensor reading.*

Option AG5 THREE-STAGE CONTROL FOR UNITS WITH THREE (3) FURNACES: Each furnace is equipped with a single-stage gas valve. The gas valves are staged in sequence by two (2) unit-mounted, two-stage ductstats (60°-110°F). The furnace nearest the blower is staged first, the center furnace is staged second, and the downstream furnace is staged last. Applicable only to packaged systems with three furnace sections.*

Option AG19 ELECTRONIC THREE-STAGE CONTROL FOR UNITS WITH THREE (3) FURNACE SECTIONS USING A DUCTSTAT (50°-130°F) WITH REMOTE TEMPERATURE ADJUSTMENT: Same type of control as Option AG5, but the ductstat has a remote temperature selector. Includes factory-installed sensor and field-installed remote temperature-selector module with two adjustable stage-adder modules.*

Option AG20 ELECTRONIC THREE-STAGE CONTROL FOR UNITS WITH THREE (3) FURNACE SECTIONS USING A DUCTSTAT (50°-130°F) WITH REMOTE TEMPERATURE ADJUSTMENT AND TEMPERATURE DISPLAY: Same as Option AG19, plus a digital (liquid crystal) temperature-display module that provides selectable set point and continuous display of sensor reading.*

Option AG8 ELECTRONIC MODULATION (55°-90°F) WITH DUCTSTAT: Solid state control system, providing close temperature control through regulated manifold pressure. On a call for heat from a unit-mounted ductstat, controls modulate between 50% and 100%, as required. Units with two or three furnace sections include an outside air controller. When setpoint temperature is reached, one or two furnaces will be shut down providing 25% minimum system firing rate with two furnaces and 16-2/3% minimum with three furnaces. A room override thermostat (Option CL9) is available for use with this system. Temperature range 55° - 90°F.

Option AG9 ELECTRONIC MODULATION (55°-90°F) WITH DUCTSTAT AND REMOTE TEMPERATURE SELECTION: Control is the same as Option AG8 except that the duct sensor setpoint may be reset from a remote selector. Units with two or three furnace sections include an outside air controller. When setpoint temperature is reached, one or two furnaces will be shut down providing 25% minimum system firing rate with two furnaces and 16-2/3% minimum with three furnaces. Remote temperature selector is included. A room override thermostat (Option CL9) is available for use with this system. (See illustration)

AG21 ELECTRONIC MODULATION WITH DDC CONTROL: Used with customer-supplied 4-20MA or 0-10V input signal. Includes Maxitrol A200/SC10C-B6S1 signal conditioner and special modulating gas regulator.

*A APPLICATION NOTE: If the installation of a packaged unit with more than one furnace section requires that any of the controls in this table be used in conjunction with an override thermostat, additional factory-installed relays are required. Since this application is not covered by “normal” control sequence, the additional relays (Option BG2) must be specified.

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<td>2</td>
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<td>4</td>
<td>2</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>AG17, AG18, AG19</td>
<td>RPBL</td>
<td>1500, 1200</td>
<td>6</td>
<td>N/A</td>
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<td>6</td>
<td>N/A</td>
<td>3</td>
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</table>

Form C-AH Page 16
Option AG39 ELECTRONIC MODULATION (SEE FIRING RATE TURNDOWN PERCENT IN TABLE BELOW): **Available with natural gas only on Models /RPBL & SSCBL Size 400**

**Description**
- Reznor ® Option AG39 is an electronic modulation gas control that will provide precise control of discharge air temperature over an increased range of outside air conditions. It is now available on selected Models of Reznor gas furnaces.
- This option allows the furnace input ratio to be fully modulated between 100% and 28 to 20%.
- The part-load thermal efficiency of this system complies with and exceeds the current seventy-five percent minimum requirement of ASHRAE standard 90.1 for part-load efficiencies. This system offers an average thermal efficiency over the range of modulation that is equal to or exceeds the full input rate thermal efficiency.
- Furnaces with Option AG39 require stainless steel burners, a stainless steel heat exchanger, and a stainless steel bottom pan. The gas train includes a single-stage gas valve, a modulating valve, and two gas pressure switches. The burner rack is equipped with one flash carry-over and a regulated gas lighter tube system. The carry-over lighter tube receives its gas supply through the regulator, simultaneously with the gas to the burner. Control of the system is through a Maxitrol #A1092 amplifier with a corresponding remote temperature dial (Maxitrol® #TD92-0509).

**Sensor Location**
- The duct temperature sensor is factory installed in the cabinet leg. Although the sensor has a mixing tube, at this distance from the discharge it does not receive a true mix, so the temperature read by the sensor will be slightly higher than the actual air entering the ductwork. The system will provide comfort level heat if the selector is set slightly lower to compensate for this reading. The offset temperature will vary with the application. If a direct correlation of these two temperatures is required, move the duct sensor to a location in the ductwork about 10-12 feet from the furnace discharge.

**Sample Specification**
- The unit shall have electronic modulation offering at least full modulation to 28% of full fire (capacity) input rate.
- Modulating gas control shall be certified by CSA for use in The United States and Canada.
- The furnace shall maintain an average thermal efficiency over the range of modulation that is equal to or exceeds the full input rate thermal efficiency.
- The furnace shall ignite at any fire rate within its modulation range, not just high fire on start.

Option AG40 ELECTRONIC MODULATION (SEE FIRING RATE TURNDOWN PERCENT IN TABLE BELOW) WITH DDC CONTROL: Same system as AG39 but includes signal conditioner for use with customer-supplied 4-20MA or 0-10V input signal. **(Available with natural gas only on Model RPBL & SSCBL Size 400)**

Option AG41 ELECTRONIC MODULATION (SEE FIRING RATE TURNDOWN PERCENT IN TABLE BELOW) FOR RPBL UNITS WITH TWO (2) OR THREE (3) FURNACES: Same system as AG39 (electronic modulation gas control on the first furnace) with a two-stage with outside air temperature control on the other(s). **(Available on Models SSCBL & RPBL sizes 500 - 1200)**

Option AG42 ELECTRONIC MODULATION (SEE FIRING RATE TURNDOWN PERCENT IN TABLE BELOW) WITH DDC CONTROL FOR RPBL UNITS WITH TWO (2) OR THREE (3) FURNACES: Same system as AG40 (electronic modulation gas control on the first furnace with signal conditioner for use with customer-supplied 4-20MA or 0-10V input signal) with a two-stage with outside air temperature control on the other(s). **(Available on Models SSCBL & RPBL sizes 500 - 1200)**

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### Options AG39, 40, 41 and 42 are available on:

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<th>Input Range</th>
<th>Gas Supply Pressure Required</th>
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<td>400</td>
<td>6” w.c. 14.9 mbar</td>
</tr>
<tr>
<td>RPBL/SSCBL</td>
<td>500</td>
<td>5” w.c. 12.5 mbar</td>
</tr>
<tr>
<td>RPBL/SSCBL</td>
<td>600</td>
<td>5” w.c. 12.5 mbar</td>
</tr>
<tr>
<td>RPBL/SSCBL</td>
<td>800</td>
<td>6” w.c. 14.9 mbar</td>
</tr>
<tr>
<td>RPBL/SSCBL</td>
<td>1200</td>
<td>6” w.c. 14.9 mbar</td>
</tr>
</tbody>
</table>

---

**APPLICATION NOTE**: If the installation of a packaged unit with more than one furnace section requires that any of the controls in this table be used in conjunction with an override thermostat, additional factory-installed relays are required. Since this application is not covered by “normal” control sequence, the additional relays (Option BG2) must be specified.
INLET AIR CONTROL SYSTEMS

CONTROL OPTIONS (cont’d)

<table>
<thead>
<tr>
<th>Option</th>
<th>Horiz. Inlet Air Opening</th>
<th>30% Horiz. O/A Dampers</th>
<th>O/A Dampers</th>
<th>Damper Motor</th>
<th>30% O/A Hood</th>
<th>Damper Motor</th>
<th>Modulating Damper Motor</th>
<th>Mixed Air Controller</th>
<th>Potentiometer</th>
<th>Warm-Up Control</th>
<th>Optional O/A Changeover</th>
<th>Remote Potentiometer</th>
<th>Remote Pressure Null Switch</th>
</tr>
</thead>
<tbody>
<tr>
<td>STD</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>AR4</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>AR6</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AR7</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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</tr>
<tr>
<td>AR8</td>
<td>X</td>
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<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>AR15</td>
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<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>AR17</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>AR18</td>
<td>X</td>
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<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>AR23</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>AR24</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>AR25</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Outdoor units only.

Option AR4 - Bottom Return Air Inlet, 100% Return Air Inlet only - Designed for 100% recirculated heating system. **OUTDOOR UNITS ONLY.**

Option AR6 - 30% Outside Horizontal Air Inlet, Bottom Return Air Inlet, 30% Outside Air Hood, Outside Air Dampers: 100% Return Air Inlet, 30% Outside Air Inlet with Hood (see Outside Air Hood section) and Manual Outside Air Damper - Supplies constant 30% or less outside air to recirculating heating system. Outside air hood is shipped separately for field installation. **OUTDOOR UNITS ONLY.**

Option AR7 - 30% Outside Horizontal Air Inlet, Bottom Return Air Inlet, 30% Outside Air Hood, Outside Air Dampers, Damper Motor: 100% Return Air Inlet, 30% Outside Air Inlet with Hood (see Outside Air Hood section) and Motorized Outside Air Damper - Supplies 30% outside air to a recirculating heating system at specific times, as controlled by a time clock or switch. On shutdown, the outside air damper closes. Outside air hood is shipped separately for field installation.

Option AR8 - Outside Horizontal Air Inlet, Outside Air Dampers, Damper Motor (2-Position): 100% Outside Air Inlet, with Two-Position (open/closed) Motorized Damper - 100% outside air system which provides makeup air intermittently, usually in unison with a building exhauster. Outside air damper opens when unit is on; closes when units is off.
CONTROL OPTIONS (cont’d)

Option AR15 - Outside Horizontal Air Inlet, Bottom Return Air Inlet, Outside Air Dampers, Damper Motor (Modulating), Return Air Dampers, Mixed Air Controller, Potentiometer, Warm Up Control: 100% Outside Air and 100% Return Air Inlets with Dampers, Modulating Damper Motor, Potentiometer, Mixed Air Controller and Warm-up Control (ASHRAE Cycle II) - 100% return air on warm-up and automatically controlled mix of outside/return air to meet the temperature setting of the mixed air controller after warm-up. A minimum amount of outside air is allowed after warm-up as determined by the potentiometer setting. When used with mechanical cooling, optional air change over control may be added. An outside air change over control (not included in Option AR15 package) closes outside air dampers when the entering air reaches a set temperature (Usually 75 degrees F).

Option AR17 - Outside Horizontal Air Inlet, Bottom Return Air Inlet, Outside Air Dampers, Damper Motor (2-Position), Return Air Dampers: 100% Outside Air and 100% Return Air Inlets with Dampers and a Two-Position Damper Motor - 100% return air or 100% outside air as controlled by a switch or time clock. ON shutdown, the outside air damper closes.

Option AR18 - Outside Horizontal Air Inlet, Bottom Return Air Inlet, Outside Air Dampers, Damper Motor (Modulating), Return Air Dampers, Remote Potentiometer: 100% Outside Air and 100% Return Air Inlets with Dampers, a Modulating Damper Motor and Potentiometer - Mixture of return and outside air as controlled by a manually set remote potentiometer. On shutdown, the outside air damper closes.

Option AR23 - Outside Horizontal Air Inlet, Bottom Return Air Inlet, Outside Air Dampers, Damper Motor (Modulating), Return Air Dampers, Remote Pressure Null Switch: 100% Outside Air and 100% Return Inlets with Dampers, a Modulating Damper Motor and Pressure Null Switch - Mixture of return and outside air as automatically controlled by a remote pressure null switch. On shutdown, the outside air damper closes.

Option AR24 - Outside Horizontal Air Inlet, Bottom Return Air Inlet: 100% Outside Air and 100% Return Air Inlets, without Factory-Supplied Dampers - Designed for installation of field supplied damper system.

Option AR25 - Outside Horizontal Air Inlet, Bottom Return Air Inlet, Outside Air Dampers, Damper Motor with DDC, Return Air Dampers: Includes outside air damper and return air damper linked together with a modulating damper motor with an interface module to accept a 0 - 10 volt, or 4 - 20 mA signal from a D.D.C. system, to position the dampers for mixed air. Standard Discharge - Installation that requires connection to horizontal ductwork before turning downward or where immediate downturn ductwork with horizontal connection is field supplied.

3/4” Duct Flange designed for “U” channel top/bottom ductwork connection and “L” type on each side

DISCHARGE AIR OPTIONS

<table>
<thead>
<tr>
<th></th>
<th>Horiz. Discharge Air Opening w/ Duct Flanges</th>
<th>Downturn Plenum for Vertical Discharge Air</th>
<th>Vertical Discharge Air Opening w/ Duct Flanges</th>
<th>2-Position Dampers</th>
</tr>
</thead>
<tbody>
<tr>
<td>STD</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>AQ5</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>AQ8</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

Option AQ5 - Installation where vertical ductwork is attached and sealed directly to the duct flange on the bottom of the downturn plenum cabinet.

Downturn Plenum Cabinet
1” Duct Flange for slip-type connection (flange is perpendicular to the cabinet)

Option AQ8 - Installation where vertical ductwork is attached and sealed directly to the duct flange on the bottom of the downturn plenum cabinet. The two-position (open/close) dampers in the discharge opening are designed to isolate the unit from the building atmosphere when the system is not operating. The damper motor is located inside the downturn plenum cabinet.

Downturn Plenum Cabinet
Two-Position Dampers
Direct-Coupled Motor (rated for use in discharge airstream)
1” Duct Flange for slip-type connection (flange is perpendicular to the cabinet)
OUTSIDE AIR HOOD OPTION
Screened Outside Air Hood for
100% Outside Air Inlet Opening

DESCRIPTION

Option AS2, Outside Air Hood, is a weatherized screened hood designed to be field assembled and installed around the horizontal inlet air opening of a Model RPBL or RBL. The air hood includes a pre-assembled louver assembly designed to help eliminate moisture from the inlet air.

### Cabinet Blowers

<table>
<thead>
<tr>
<th>Cabinet Blowers</th>
<th>Models</th>
<th>Size</th>
<th>Width of Outside Air Hood</th>
</tr>
</thead>
<tbody>
<tr>
<td>RPBL</td>
<td>500, 600</td>
<td>47 7/8</td>
<td>1,216</td>
</tr>
<tr>
<td>RPBL</td>
<td>700, 1050</td>
<td>53 3/8</td>
<td>1,356</td>
</tr>
<tr>
<td>RBL</td>
<td>400, 800, 1200, 1600</td>
<td>58 7/8</td>
<td>1,495</td>
</tr>
</tbody>
</table>

Note: The width of the outside air hood is the same as the width of the blower cabinet.

### 30% OUTSIDE AIR HOOD SUPPLIED WITH INLET AIR OPTIONS AR6 AND AR7
(see description in Air Control Option section)

DESCRIPTION

The outside air hood included in the inlet air options that provide 30% outside air (Options AR6 and AR7) is shipped separately for field installation. The hood is factory assembled but requires field attachment to the blower cabinet. Illustrated instructions are provided.

<table>
<thead>
<tr>
<th>MODEL</th>
<th>SIZE</th>
<th>400</th>
<th>500, 600</th>
<th>700, 1050</th>
<th>800, 1200</th>
</tr>
</thead>
<tbody>
<tr>
<td>RPBL</td>
<td>lbs.</td>
<td>96</td>
<td>87</td>
<td>92</td>
<td>96</td>
</tr>
<tr>
<td></td>
<td>(kg)</td>
<td>(44)</td>
<td>(39)</td>
<td>(42)</td>
<td>(44)</td>
</tr>
<tr>
<td>RBL</td>
<td>lbs.</td>
<td>96</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>(kg)</td>
<td>(44)</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>RPBL</th>
<th>Width of 30% Hood</th>
</tr>
</thead>
<tbody>
<tr>
<td>--</td>
<td>400 in. 58 7/8</td>
</tr>
<tr>
<td></td>
<td>(mm) (1,495)</td>
</tr>
<tr>
<td>--</td>
<td>500, 600 in. 47 7/8</td>
</tr>
<tr>
<td></td>
<td>(mm) (1,216)</td>
</tr>
<tr>
<td>--</td>
<td>700, 1050 in. 53 3/8</td>
</tr>
<tr>
<td></td>
<td>(mm) (1,356)</td>
</tr>
<tr>
<td>RBL</td>
<td>800, 1200 in. 58 7/8</td>
</tr>
<tr>
<td></td>
<td>(mm) (1,495)</td>
</tr>
</tbody>
</table>
# MOUNTING OPTIONS

## Suspension Points (Model SSCBL)

### Top View of Curb Cap Assembly

#### Suspension Point Dimensions

<table>
<thead>
<tr>
<th>SSCBL Size</th>
<th>Suspension Dimensions</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F (inches) (mm)</td>
<td>G (inches) (mm)</td>
</tr>
<tr>
<td>400</td>
<td>59 9/16 (1,513)</td>
<td>54 3/8 (1,381)</td>
</tr>
<tr>
<td>500, 600</td>
<td>48 9/16 (1,233)</td>
<td>43 3/8 (1,102)</td>
</tr>
<tr>
<td>700</td>
<td>54 1/16 (1,373)</td>
<td>48 7/8 (1,241)</td>
</tr>
<tr>
<td>800</td>
<td>59 9/16 (1,513)</td>
<td>54 3/8 (1,381)</td>
</tr>
<tr>
<td>1050</td>
<td>54 1/16 (1,373)</td>
<td>48 7/8 (1,241)</td>
</tr>
<tr>
<td>1200</td>
<td>59 9/16 (1,513)</td>
<td>54 3/8 (1,381)</td>
</tr>
</tbody>
</table>

*Dimensions E and H listed here do not apply to a system with a field-attached cooling coil cabinet (Option AU2 or AU3); see NOTE in FIGURE 4.*
Curb Dimensions (Model RPBL & RBL)

Reznor optional roof curbs are available in sizes to fit all Reznor packaged heating/makeup air systems. Roof curbs are shipped in pre-assembled sections constructed of 16 gauge aluminized steel, 2x6 wood nailers and 3# fiberglass insulation. Field assembly and installation are required.

Dimensions for Bottom Downturn Duct Flange

Bottom Duct Connection Height

* Discharge Air Only
## Curb Dimensions (Model RPBL)

The diagram illustrates the curb dimensions for different models, with measurements provided in both inches and millimeters. The curb consists of several parts: A for the front, B for the side, C for the top, D for the opening, G for the return duct opening, H for the supply duct opening, and J for the curb opening. The dimensions are specified for different sizes, and additional options are described for various configurations.

### Table: Roof Curb Dimensions for Model RPBL

#### Option CJ1 - Roof Curb for Heater Only

<table>
<thead>
<tr>
<th>SIZE</th>
<th>A (in.)</th>
<th>B (in.)</th>
<th>C (mm)</th>
<th>D (mm)</th>
<th>G (mm)</th>
<th>H (mm)</th>
<th>J (mm)</th>
<th>Weight (lbs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>400</td>
<td>106 1/4</td>
<td>(2,699)</td>
<td>54 1/2</td>
<td>(1,373)</td>
<td>78 1/2</td>
<td>(1,987)</td>
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<td>47 5/8</td>
</tr>
<tr>
<td>500, 600</td>
<td>132 1/4</td>
<td>(3,359)</td>
<td>49 1/16</td>
<td>(1,246)</td>
<td>104 1/2</td>
<td>(2,645)</td>
<td>45 5/16</td>
<td>800</td>
</tr>
<tr>
<td>700</td>
<td>158 1/4</td>
<td>(4,020)</td>
<td>49 1/16</td>
<td>(1,246)</td>
<td>130 1/2</td>
<td>(3,310)</td>
<td>45 5/16</td>
<td>1,050</td>
</tr>
<tr>
<td>1050</td>
<td>186 1/4</td>
<td>(4,727)</td>
<td>49 1/16</td>
<td>(1,246)</td>
<td>130 1/2</td>
<td>(3,310)</td>
<td>45 5/16</td>
<td>1,200</td>
</tr>
<tr>
<td>1200</td>
<td>204 1/4</td>
<td>(5,199)</td>
<td>49 1/16</td>
<td>(1,246)</td>
<td>130 1/2</td>
<td>(3,310)</td>
<td>45 5/16</td>
<td>1,350</td>
</tr>
</tbody>
</table>

#### Option CJ2 - Roof Curb for Heater Plus Factory-Installed Downturn Plenum (Option AQ5 or AQ8)

<table>
<thead>
<tr>
<th>SIZE</th>
<th>A (in.)</th>
<th>B (in.)</th>
<th>C (mm)</th>
<th>D (mm)</th>
<th>G (mm)</th>
<th>H (mm)</th>
<th>J (mm)</th>
<th>Weight (lbs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>400</td>
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<td>(3,816)</td>
<td>54 1/2</td>
<td>(1,373)</td>
<td>146 1/2</td>
<td>(3,712)</td>
<td>50 13/16</td>
<td>47 5/8</td>
</tr>
<tr>
<td>500, 600</td>
<td>185 1/4</td>
<td>(4,697)</td>
<td>49 1/16</td>
<td>(1,246)</td>
<td>161 1/2</td>
<td>(4,092)</td>
<td>50 13/16</td>
<td>800</td>
</tr>
<tr>
<td>700</td>
<td>210 3/4</td>
<td>(5,337)</td>
<td>49 1/16</td>
<td>(1,246)</td>
<td>167</td>
<td>(4,224)</td>
<td>45 5/16</td>
<td>1,050</td>
</tr>
<tr>
<td>1050</td>
<td>235 1/4</td>
<td>(5,933)</td>
<td>49 1/16</td>
<td>(1,246)</td>
<td>193</td>
<td>(4,902)</td>
<td>45 5/16</td>
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</tr>
<tr>
<td>1200</td>
<td>260 1/4</td>
<td>(6,607)</td>
<td>49 1/16</td>
<td>(1,246)</td>
<td>198 1/2</td>
<td>(5,012)</td>
<td>45 5/16</td>
<td>1,350</td>
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</table>

#### Option CJ3 - Roof Curb for Heater Plus Field-Installed Cooling Coil Cabinet (Option AU2 or AU3)

<table>
<thead>
<tr>
<th>SIZE</th>
<th>A (in.)</th>
<th>B (in.)</th>
<th>C (mm)</th>
<th>D (mm)</th>
<th>G (mm)</th>
<th>H (mm)</th>
<th>J (mm)</th>
<th>Weight (lbs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>400</td>
<td>174 1/4</td>
<td>(4,416)</td>
<td>54 1/2</td>
<td>(1,373)</td>
<td>170 1/2</td>
<td>(4,331)</td>
<td>50 13/16</td>
<td>227</td>
</tr>
<tr>
<td>500, 600</td>
<td>189 1/4</td>
<td>(4,807)</td>
<td>49 1/16</td>
<td>(1,246)</td>
<td>185 1/2</td>
<td>(4,712)</td>
<td>39 13/16</td>
<td>253</td>
</tr>
<tr>
<td>700</td>
<td>204 1/4</td>
<td>(5,199)</td>
<td>49 1/16</td>
<td>(1,246)</td>
<td>191</td>
<td>(4,851)</td>
<td>45 5/16</td>
<td>289</td>
</tr>
<tr>
<td>1050</td>
<td>220 3/4</td>
<td>(5,607)</td>
<td>49 1/16</td>
<td>(1,246)</td>
<td>217</td>
<td>(5,512)</td>
<td>45 5/16</td>
<td>306</td>
</tr>
<tr>
<td>1200</td>
<td>226 1/4</td>
<td>(5,747)</td>
<td>54 1/2</td>
<td>(1,373)</td>
<td>222 1/2</td>
<td>(5,652)</td>
<td>50 13/16</td>
<td>342</td>
</tr>
</tbody>
</table>

#### Option CJ5 - Roof Curb for Heater Plus Field-Installed Cooling Coil Cabinet WITH Downturn Plenum (Option AU11, AU12, AU13 or AU14)

<table>
<thead>
<tr>
<th>SIZE</th>
<th>A (in.)</th>
<th>B (in.)</th>
<th>C (mm)</th>
<th>D (mm)</th>
<th>G (mm)</th>
<th>H (mm)</th>
<th>J (mm)</th>
<th>Weight (lbs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>400</td>
<td>174 1/4</td>
<td>(4,416)</td>
<td>54 1/2</td>
<td>(1,373)</td>
<td>170 1/2</td>
<td>(4,331)</td>
<td>50 13/16</td>
<td>227</td>
</tr>
<tr>
<td>500, 600</td>
<td>189 1/4</td>
<td>(4,807)</td>
<td>49 1/16</td>
<td>(1,246)</td>
<td>185 1/2</td>
<td>(4,712)</td>
<td>39 13/16</td>
<td>253</td>
</tr>
<tr>
<td>700</td>
<td>204 1/4</td>
<td>(5,199)</td>
<td>49 1/16</td>
<td>(1,246)</td>
<td>191</td>
<td>(4,851)</td>
<td>45 5/16</td>
<td>289</td>
</tr>
<tr>
<td>1050</td>
<td>220 3/4</td>
<td>(5,607)</td>
<td>49 1/16</td>
<td>(1,246)</td>
<td>217</td>
<td>(5,512)</td>
<td>45 5/16</td>
<td>306</td>
</tr>
<tr>
<td>1200</td>
<td>226 1/4</td>
<td>(5,747)</td>
<td>54 1/2</td>
<td>(1,373)</td>
<td>222 1/2</td>
<td>(5,652)</td>
<td>50 13/16</td>
<td>342</td>
</tr>
</tbody>
</table>

*C and D are roof opening dimensions

---

**Form C-AH Page 23**
Indirect-fired packaged Reznor heating/makeup air systems, Model Series, RPBL, and SSCBL, are available with an optional cooling coil cabinet that houses a large finned surface refrigerant (DX) or chilled water cooling coil. Cooling coils are available in capacities from 5 to over 40 tons (60 to 480 MBH). Depending on the size of the system, the cabinets accommodate coils with a finned surface area from 11.2 to 14.9 square feet. Large finned surface areas aid coil performance by reducing face velocities, lowering coil pressure drops, and increasing cooling capacity.

Cabinets are fully insulated with weatherproof construction for outdoor application. Standard construction is single-wall 20 gauge galvalume steel. Optional double-wall cabinet construction is available. The cooling coil cabinet has a drain trough for positive drainage under all operating conditions in compliance with ASHRAE Standard 62-1989. The drain trough is provided with a 1” FPVC connection on the exterior of the cabinet. For down discharge, an optional downturn plenum cabinet with or without discharge dampers is available.

The performance data is certified in accordance with ARI Standard 410.

For coil capacities not outlined in these tables or for special coil requirements, contact your Reznor Sales Representative.

Selecting the proper cooling coil is vital to air handling equipment performance and cost. The correctly sized coil provides the desired dehumidification and sensible cooling under all possible internal and external loads that the building may experience. In order to properly select the coil capacity, a detailed internal and external load analysis must be performed. Caution must be taken to ensure that the percentage of outside air brought into the building meets current codes. The percentage of outside air for most applications is approximately 25%. Some current codes require greater percentages of outside air, up to 100% for densely populated structures where contaminants become a significant health risk, such as schools. The current ASHRAE recommendations on proper percentages of outside air can be found in ASHRAE Standard 62-1999 “Ventilation for Acceptable Indoor Air Quality”.

Review the coil performance tables for general capacity data at standard outside air (95°/75°F) and return air (80°/67°F) conditions. The preferred method of selection is to use the Reznor Coil Selection Software. If you do not have a copy, contact your local Reznor Sales Representative.

Thermal expansion valves (TXV) and auxiliary connections for hot gas bypass are optionally available from about 5 to 15 tons per circuit. The parts used depend on the distributor dimensions.

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AU2</td>
<td>Cooling Coil Cabinet for a Chilled Water Coil</td>
</tr>
<tr>
<td>AU3</td>
<td>Cooling Coil Cabinet for a DX Coil</td>
</tr>
<tr>
<td>AU11</td>
<td>Cooling Coil Cabinet for a Chilled Water Coil plus a Downturn Plenum Cabinet</td>
</tr>
<tr>
<td>AU12</td>
<td>Cooling Coil Cabinet for a Chilled Water Coil plus a Downturn Plenum Cabinet with 2-Position Discharge Dampers</td>
</tr>
<tr>
<td>AU13</td>
<td>Cooling Coil Cabinet for a DX Coil plus a Downturn Plenum Cabinet</td>
</tr>
<tr>
<td>AU14</td>
<td>Cooling Coil Cabinet for a DX Coil plus a Downturn Plenum Cabinet with 2-Position Discharge Dampers</td>
</tr>
</tbody>
</table>

Additional Coil Options:
- Phenolic coatings
- Copper fins
- Stainless steel casing
Discharge Damper Note: The two-position discharge dampers in Option AU12 fit in the discharge air opening. The damper motor fits inside the downturn plenum cabinet.

Dimensions (inches ± 1/8) and Approximate Weights (lbs)

<table>
<thead>
<tr>
<th>Furnace Size MBH</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>J</th>
<th>Cabinet Wt [lbs]</th>
</tr>
</thead>
<tbody>
<tr>
<td>400</td>
<td>in.</td>
<td>(1.492)</td>
<td>1.156</td>
<td>(1.426)</td>
<td>1.711</td>
<td>(1.786)</td>
<td>(2.397)</td>
<td>(2.346)</td>
<td>(879)</td>
</tr>
<tr>
<td>500, 600</td>
<td>in.</td>
<td>(1.213)</td>
<td>(876)</td>
<td>(1.146)</td>
<td>(1.432)</td>
<td>(1.508)</td>
<td>(2.118)</td>
<td>(1.457)</td>
<td>(2.067)</td>
</tr>
<tr>
<td></td>
<td>lbs.</td>
<td>(394)</td>
<td>(546)</td>
<td>(179)</td>
<td>(248)</td>
<td>(179)</td>
<td>(248)</td>
<td>(179)</td>
<td>(248)</td>
</tr>
<tr>
<td>700</td>
<td>in.</td>
<td>53 1/4</td>
<td>40</td>
<td>50 5/8</td>
<td>62</td>
<td>64 7/8</td>
<td>88 7/8</td>
<td>63</td>
<td>87</td>
</tr>
<tr>
<td></td>
<td>lbs.</td>
<td>449</td>
<td>610</td>
<td>449</td>
<td>610</td>
<td>449</td>
<td>610</td>
<td>449</td>
<td>610</td>
</tr>
<tr>
<td>800</td>
<td>in.</td>
<td>(1.353)</td>
<td>(1.016)</td>
<td>(1.286)</td>
<td>(1.575)</td>
<td>(1.648)</td>
<td>(2.257)</td>
<td>(1.600)</td>
<td>(2.210)</td>
</tr>
<tr>
<td></td>
<td>lbs.</td>
<td>(204)</td>
<td>(277)</td>
<td>(204)</td>
<td>(277)</td>
<td>(204)</td>
<td>(277)</td>
<td>(204)</td>
<td>(277)</td>
</tr>
<tr>
<td>1050</td>
<td>in.</td>
<td>(1.492)</td>
<td>1.156</td>
<td>(1.426)</td>
<td>1.711</td>
<td>(1.786)</td>
<td>(2.397)</td>
<td>(2.346)</td>
<td>(879)</td>
</tr>
<tr>
<td>1200</td>
<td>in.</td>
<td>(1.492)</td>
<td>1.156</td>
<td>(1.426)</td>
<td>1.711</td>
<td>(1.786)</td>
<td>(2.397)</td>
<td>(2.346)</td>
<td>(879)</td>
</tr>
</tbody>
</table>
### Refrigerant (DX) Coil Cabinet - Options AU3, AU13, AU14

**Dimensions (inches ± 1/8) and Approximate Weights (lbs)**

<table>
<thead>
<tr>
<th>Furnace Size MBH</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E (Without Downturn)</th>
<th>F (With Downturn)</th>
<th>G</th>
<th>J</th>
<th>Cabinet Wt [lbs]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(kg)</td>
<td>(lbs)</td>
<td></td>
<td></td>
<td>(kg)</td>
</tr>
<tr>
<td></td>
<td>(1492)</td>
<td>(1156)</td>
<td>(1426)</td>
<td>(1711)</td>
<td>(1788)</td>
<td>(2397)</td>
<td>(1737)</td>
<td>(2346)</td>
<td>(879)</td>
</tr>
<tr>
<td></td>
<td>(1213)</td>
<td>(676)</td>
<td>(1146)</td>
<td>(1432)</td>
<td>(1508)</td>
<td>(2116)</td>
<td>(1457)</td>
<td>(2067)</td>
<td>(740)</td>
</tr>
<tr>
<td>700</td>
<td>53 1/4</td>
<td>40</td>
<td>50 5/8</td>
<td>62</td>
<td>64 7/8</td>
<td>88 7/8</td>
<td>63</td>
<td>87</td>
<td>31 7/8</td>
</tr>
<tr>
<td></td>
<td>(1353)</td>
<td>(1016)</td>
<td>(1286)</td>
<td>(1575)</td>
<td>(1648)</td>
<td>(2257)</td>
<td>(1600)</td>
<td>(2210)</td>
<td>(810)</td>
</tr>
<tr>
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<td>(1492)</td>
<td>(1156)</td>
<td>(1426)</td>
<td>(1711)</td>
<td>(1788)</td>
<td>(2397)</td>
<td>(1737)</td>
<td>(2346)</td>
<td>(879)</td>
</tr>
<tr>
<td>1050</td>
<td>53 1/4</td>
<td>40</td>
<td>50 5/8</td>
<td>62</td>
<td>64 7/8</td>
<td>88 7/8</td>
<td>63</td>
<td>87</td>
<td>31 7/8</td>
</tr>
<tr>
<td></td>
<td>(1353)</td>
<td>(1016)</td>
<td>(1286)</td>
<td>(1575)</td>
<td>(1648)</td>
<td>(2257)</td>
<td>(1600)</td>
<td>(2210)</td>
<td>(810)</td>
</tr>
<tr>
<td></td>
<td>(1492)</td>
<td>(1156)</td>
<td>(1426)</td>
<td>(1711)</td>
<td>(1788)</td>
<td>(2397)</td>
<td>(1737)</td>
<td>(2346)</td>
<td>(879)</td>
</tr>
</tbody>
</table>

**Discharge Damper Note:** The two-position discharge dampers in Option AU14 fit in the discharge air opening. The damper motor fits inside the downturn plenum cabinet.

---

**Form C-AH Page 26**
Overall Dimensions of Model RPBL
with Cooling Coil Cabinet, with or without downturn plenum

<table>
<thead>
<tr>
<th>SIZE</th>
<th>A</th>
<th>Unit with Cooling Coil Cabinet only</th>
<th>Unit with Cooling Coil Cabinet and Downturn Plenum</th>
</tr>
</thead>
<tbody>
<tr>
<td>400</td>
<td>in. 58 7/8</td>
<td>150 3/8</td>
<td>173 1/2</td>
</tr>
<tr>
<td></td>
<td>(mm) 1,495</td>
<td>3,820</td>
<td>4,407</td>
</tr>
<tr>
<td>500, 600</td>
<td>in. 47 1/8</td>
<td>165 3/8</td>
<td>188 1/2</td>
</tr>
<tr>
<td></td>
<td>(mm) 1,197</td>
<td>4,201</td>
<td>4,788</td>
</tr>
<tr>
<td>700</td>
<td>in. 53 3/8</td>
<td>171</td>
<td>194 1/8</td>
</tr>
<tr>
<td></td>
<td>(mm) 1,356</td>
<td>4,343</td>
<td>4,931</td>
</tr>
<tr>
<td>800</td>
<td>in. 58 7/8</td>
<td>176 3/8</td>
<td>199 1/2</td>
</tr>
<tr>
<td></td>
<td>(mm) 1,495</td>
<td>4,480</td>
<td>5,067</td>
</tr>
<tr>
<td>1050</td>
<td>in. 53 3/8</td>
<td>197</td>
<td>220 1/8</td>
</tr>
<tr>
<td></td>
<td>(mm) 1,356</td>
<td>5,004</td>
<td>5,591</td>
</tr>
<tr>
<td>1200</td>
<td>in. 58 7/8</td>
<td>202 3/8</td>
<td>225 1/2</td>
</tr>
<tr>
<td></td>
<td>(mm) 1,495</td>
<td>5,140</td>
<td>5,728</td>
</tr>
</tbody>
</table>
Dimensional Data (cont’d)

Coil Dimensions and Weights (table applies to both types of coils)

<table>
<thead>
<tr>
<th>Furnace Size</th>
<th>[A Fin Length]</th>
<th>[B coil Length]</th>
<th>Maximum Finned Surface Area</th>
<th>[8 fpi]</th>
<th>[10 fpi]</th>
<th>[12 fpi]</th>
<th>[14 fpi]</th>
</tr>
</thead>
<tbody>
<tr>
<td>MBH</td>
<td>in (mm)</td>
<td>in (mm)</td>
<td>sq. ft. (M2)</td>
<td>lbs. (kg)</td>
<td>lbs. (kg)</td>
<td>lbs. (kg)</td>
<td>lbs. (kg)</td>
</tr>
<tr>
<td>400</td>
<td>65 (1,651)</td>
<td>67 (1,702)</td>
<td>14.9 (1.36)</td>
<td>283 (128)</td>
<td>308 (140)</td>
<td>334 (152)</td>
<td>361 (164)</td>
</tr>
<tr>
<td>500, 600</td>
<td>49 (1,245)</td>
<td>51 (1,295)</td>
<td>11.2 (1.04)</td>
<td>221 (100)</td>
<td>240 (109)</td>
<td>260 (118)</td>
<td>281 (127)</td>
</tr>
<tr>
<td>700</td>
<td>57 (1,448)</td>
<td>59 (1,499)</td>
<td>13.1 (1.22)</td>
<td>252 (114)</td>
<td>274 (124)</td>
<td>297 (135)</td>
<td>321 (146)</td>
</tr>
<tr>
<td>800</td>
<td>65 (1,651)</td>
<td>67 (1,702)</td>
<td>14.9 (1.36)</td>
<td>283 (128)</td>
<td>308 (140)</td>
<td>334 (152)</td>
<td>361 (164)</td>
</tr>
<tr>
<td>1050</td>
<td>57 (1,448)</td>
<td>59 (1,499)</td>
<td>13.1 (1.22)</td>
<td>252 (114)</td>
<td>274 (124)</td>
<td>297 (135)</td>
<td>321 (146)</td>
</tr>
<tr>
<td>1200</td>
<td>65 (1,651)</td>
<td>67 (1,702)</td>
<td>14.9 (1.36)</td>
<td>283 (128)</td>
<td>308 (140)</td>
<td>334 (152)</td>
<td>361 (164)</td>
</tr>
</tbody>
</table>

Chilled Water Coil
(Coil options to be selected with Cabinet Option AU2, AU11, or AU12)

DX Coil
(Coil options to be selected with Cabinet Option AU3, AU13, or AU14)
### Heating and Cooling Airflow Ranges

#### Notes for Table:

1. Calculate Coil Face Velocity as: \[
\text{[Airflow (scfm \ [sM^3/hr]) / Finned Coil Surface Area (sq. ft. \ [M^2])]}\]

2. A general rule of thumb for required airflow is 400 scfm (680sM^3/hr) per ton of cooling for return air applications. For outside air applications, the range is approximately 150 scfm per ton to 400 scfm per ton, depending on the outdoor enthalpy and humidity ratio.

3. To avoid the possibility of condensate blow-off, the coil face velocities should not exceed 550 sfpm.

4. Conversion to standard airflow is required above 1500 ft. To convert from actual airflow (acfm) to standard airflow (scfm), see Conversion to Standard Airflow.

<table>
<thead>
<tr>
<th>Models RPBL, SSCBL</th>
<th>Blower Airflow Range</th>
<th>Cooling Standard Airflow</th>
<th>Maximum (550 SFPM)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Maximum [aM^3/hr] acfm</td>
<td>Minimum [aM^3/hr] acfm</td>
<td>Maximum [sM^3/hr] scfm</td>
</tr>
<tr>
<td>400</td>
<td>14,000</td>
<td>3,300</td>
<td>3,300</td>
</tr>
<tr>
<td>500</td>
<td>12,000</td>
<td>20,387</td>
<td>23,785</td>
</tr>
<tr>
<td>600</td>
<td>12,500</td>
<td>21,237</td>
<td>21,237</td>
</tr>
<tr>
<td>700</td>
<td>13,500</td>
<td>22,936</td>
<td>22,936</td>
</tr>
<tr>
<td>800</td>
<td>13,500</td>
<td>22,936</td>
<td>22,936</td>
</tr>
<tr>
<td>1050</td>
<td>13,500</td>
<td>22,936</td>
<td>22,936</td>
</tr>
<tr>
<td>1200</td>
<td>13,500</td>
<td>22,936</td>
<td>22,936</td>
</tr>
</tbody>
</table>

#### Enthalpy of Saturated Air for Various Wet Bulb Temperatures

<table>
<thead>
<tr>
<th>Wet Bulb Temp, [deg.F]</th>
<th>Enthalpy [Btu / lb]</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>20.4</td>
</tr>
<tr>
<td>50.5</td>
<td>20.6</td>
</tr>
<tr>
<td>51</td>
<td>20.9</td>
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<td>51.5</td>
<td>21.2</td>
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<td>52</td>
<td>21.4</td>
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<td>52.5</td>
<td>21.7</td>
</tr>
<tr>
<td>53</td>
<td>22</td>
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<tr>
<td>53.5</td>
<td>22.3</td>
</tr>
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<td>54</td>
<td>22.6</td>
</tr>
<tr>
<td>54.5</td>
<td>22.9</td>
</tr>
<tr>
<td>55</td>
<td>23.2</td>
</tr>
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<td>55.5</td>
<td>23.5</td>
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<td>56</td>
<td>23.8</td>
</tr>
<tr>
<td>56.5</td>
<td>24.1</td>
</tr>
<tr>
<td>57</td>
<td>24.4</td>
</tr>
</tbody>
</table>

**General Note:** Enthalpy is approximately constant with constant wet bulb temperature. There is a slight variation with dry bulb temperature, but the variation is typically negligible over the range of dry bulb temperatures common to HVAC applications.
<table>
<thead>
<tr>
<th>Furnace Size</th>
<th>2 Row DX Coils (R410A)</th>
<th>Total MBH</th>
<th>SHR</th>
<th>Leaving Air DB/ WB (°F)</th>
<th>Air PD (in. WC)</th>
<th>Total MBH</th>
<th>SHR</th>
<th>Leaving Air DB/ WB (°F)</th>
<th>Air PD (in. WC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3,300</td>
<td>60 .89 62.5 / 59.7 53.5 .06 81 .89 52.7 / 52.4 53.1 .08</td>
<td>3,800 91 .88 63.5 / 60.4 53.9 .08 94 .90 61.1 / 58.8 54.3 .17</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4,500</td>
<td>69 .92 64.3 / 59.6 54.1 .10 95 .93 59.2 / 56.0 54.0 .13</td>
<td>5,200 73 .94 65.1 / 58.4 54.2 .13 102 .95 60.1 / 58.5 54.3 .17</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5,900</td>
<td>77 .96 65.8 / 58.8 54.5 .15 108 .98 60.9 / 57.0 54.5 .19</td>
<td>7,400 91 .97 66.3 / 59.0 54.5 .16 113 .98 63.3 / 58.1 54.5 .22</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8,069</td>
<td>85 .10 66.7 / 59.2 54.5 .17 118 .99 64.5 / 58.7 54.5 .24</td>
<td>119 .99 65.5 / 59.4 54.5 .24</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3,300</td>
<td>69 .82 64.0 / 58.3 54.6 .06 94 .82 58.2 / 55.7 54.2 .08</td>
<td>3,900 75 .83 65.1 / 58.9 55.2 .08 103 .84 59.4 / 56.4 54.6 .11</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4,500</td>
<td>80 .85 65.9 / 59.4 55.5 .10 110 .86 60.5 / 57.1 55.1 .14</td>
<td>5,200 86 .86 66.7 / 59.8 55.7 .13 105 .84 62.3 / 58.6 55.6 .17</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5,900</td>
<td>91 .87 67.5 / 60.2 55.9 .16 113 .85 63.0 / 59.0 56.7 .21</td>
<td>7,400 107 .89 68.0 / 60.5 56.1 .19 127 .00 64.3 / 59.6 56.8 .27</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8,069</td>
<td>111 .90 68.5 / 60.8 56.3 .22 133 .00 64.8 / 59.8 56.8 .32</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Notes for Table:**
1) Available for one external circuit, one distributor only.
2) Based on 3/4" tube OD with 1" tube spacing, circuited for refrigerant velocity > 1000 fpm, refrigerant PO < 10 psi.
3) Multiply Total MBH by SHR to get Sensible MBH.
4) Values shown are based on 45° SST, 100° LLT, 10° superheat. Entering DB is based on WB shown at 45% RH (DB has minor impact on capacity and SHR). Capacities will be lower at higher evaporator SST's (not recommended for outside air) and capacities will be lower at higher evaporator SST's. Evaporator plots are produced by the coil selection software.
5) Available fin spacings are 8, 10, 12, 14. Available tube diameters are 3/8" and 1/2".
6) The “minimum coil” is 8 ft/min at the minimum finned height resulting in less than 500 fpm face velocity when possible. The “maximum coil” is 14 ft/min with the maximum allowable finned height. Absolute maximum face velocity is 550 fpm.
## COOLING PERFORMANCE TABLES (cont’d)

**Models RPBL & SSCBL with 3 Row DX Coils**

**Table 3**: Row DX Coils (R410A)

<table>
<thead>
<tr>
<th>Furnace Size</th>
<th>400, 800, 1200</th>
<th>500, 600</th>
<th>700, 1050</th>
</tr>
</thead>
<tbody>
<tr>
<td>3,300</td>
<td>81 .688 59.2 / 55.9</td>
<td>53.8 .10</td>
<td>102 .85 54.1 / 53.5</td>
</tr>
<tr>
<td>4,500</td>
<td>95 .89 61.2 / 57.1</td>
<td>54.6 .17</td>
<td>125 .89 55.7 / 54.8</td>
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<td>5,200</td>
<td>102 .91 62.1 / 57.5</td>
<td>55.0 .22</td>
<td>136 .92 56.5 / 55.4</td>
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<td>5,900</td>
<td>104 .90 62.4 / 58.3</td>
<td>55.7 .24</td>
<td>146 .94 57.1 / 55.9</td>
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<td>107 .79 63.4 / 58.7</td>
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<td>152 .79 57.3 / 56.3</td>
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<td>160 .69 58.3 / 57.5</td>
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<td>58.2 .36</td>
<td>166 .69 59.8 / 58.7</td>
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</table>

**Notes for Table**:  
1) Available with 1 or 2 external circuits (distributors) in interlaced configuration. Circuit capacities (distributors) do not have to be equal.  
2) Based on 3/4” or 1/2” tube OD with 1.25” tube spacing (1.00” available), circuited for refrigerant velocity >1000 fpm, refrigerant PD < 10 psi. Some discontinuities may be noted in MBH, SHR, Air PD, etc. due to changes in tube OD and circuiting in order to maintain adequate refrigerant velocity and PD.  
3) Multiply Total MBH by SHR to get sensible MBH.  
4) Values shown are based on 45°F SST, 100°F LT, 10°F superheat. Entering DB is based on WB shown at 45% RH (DB has minor impact on capacity and SHR). Capacities will be lower at higher evaporator SST’s (not recommended for outside air) and capacities will be lower at higher evaporator SST’s.  
5) Available fin spacings are 8, 10, 12, 14. Available tube diameters are 3/8” and 1/2”.  
6) The “minimum coil” is 8 fpi at the minimum finned height resulting in less than 500 fpm face velocity when possible. The “maximum coil” is 14 fpi with the maximum allowable finned height. Absolute maximum face velocity is 550 fpm.
## COOLING PERFORMANCE TABLES (cont’d)

### Models RPBL & SSCBL with 4 Row DX Coils

<table>
<thead>
<tr>
<th>Furnace Size</th>
<th>40 Row DX Coils (R410A)</th>
<th>Minimum Coil</th>
<th>Maximum Coil</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Total MBH</td>
<td>SHR</td>
<td>Leaving Air DB/DB (°F)</td>
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<td>65°F</td>
<td>300</td>
<td>111</td>
<td>58.2 / 56.4</td>
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<td>70°F</td>
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<td>121</td>
<td>58.3 / 56.7</td>
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<td>75°F</td>
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<td>60.3 / 57.6</td>
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<td>80°F</td>
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<td>148</td>
<td>61.2 / 58.2</td>
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<td>85°F</td>
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<td>61.4 / 58.3</td>
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<td>90°F</td>
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<td>61.9 / 58.6</td>
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<td>400</td>
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<td>62.4 / 58.9</td>
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<td>100°F</td>
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<td>125°F</td>
<td>740</td>
<td>246</td>
<td>63.7 / 60.3</td>
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</table>

### Notes for Table:

1. Available with 1 or 2 external circuits (distributors) in interlaced configuration. Circuit capacities (distributors) do not have to be equal. Circuit capacity may be limited to 25 tons per circuit due to distributor size. Special configurations may be available at additional cost.
2. Based on 3/8" or 1/2" tube OD with 1.25" tube spacing (1.00" available), circulated for refrigerant velocity > 1000 fpm, refrigerant P < 10 psi. Some discontinuities may be noted in MBH, SHR, Air PD, etc due to changes in tube OD and circuiting in order to maintain adequate refrigerant velocity and PD.
3. Multiply Total MBH by shr to get sensible SHR.
4. Values shown are based on 45°F SST, 100°F LTT, 10°F superheat. Entering DB is based on WB shown at 45% RH (DB has minor impact on capacity and SHR). Capacities will be higher at lower evaporator SST’s (not recommended for outside air) and capacities will be lower at higher evaporator SST’s. Evaporator plots are produced by the coil selection software.
5. Available fin spacings are 8, 10, 12, 14. Available tube diameters are 3/8" and 1/2".
6. The "minimum coil" is 5 fpm at the minimum finned height resulting in less than 500 fpm face velocity when possible. The "maximum coil" is 14 fpm with the maximum allowable finned height. Absolute maximum face velocity is 550 fpm.
## Cooling Performance Tables (cont'd)

### Coils Generally for 100% O/A Application in Warm & Humid Climates, Dehumidification

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<th>Maximum Coil</th>
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## COOLING PERFORMANCE TABLES (cont’d)

### Models RPBL with Chilled Water Coils

**Performance based on entering air conditions** – 80°F Dry Bulb and 67°F Wet Bulb

Capacity based on 80°F EDB, 67°F EWB, 45°F Entering Water, 70 GPM

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<th>Furnace Models</th>
<th>Cooling Airflow (scfm)</th>
<th>Face Velocity (sfpm)</th>
<th>Fin Spacing (fpi)</th>
<th>Total MBH</th>
<th>Sens. MBH</th>
<th>DB (°F)</th>
<th>WB (°F)</th>
<th>APD (in. w.c.)</th>
<th>FPD (ft. w.c.)</th>
<th>Total MBH</th>
<th>Sens. MBH</th>
<th>DB (°F)</th>
<th>WB (°F)</th>
<th>APD (in. w.c.)</th>
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### CONVERSIONS:

1 m³/s = 2120 cfm
1 m/s = 197 fpdm
1 ton cooling = 1/12 mbh
1 kW = 3.41 mbh

\[ (°F-32) \times \frac{5}{9} = °C \]

1 in wc = 249 pascals
1 lb = 0.45 kg

### NOTES:

1) Coil Performance Data certified in accordance with ARI Standard 410
2) Maximum recommended coil face velocity is 550 sfpm
3) Consult your Sales Representative for special coil requirements
### Models SSCBL with Chilled Water Coils

**Performance based on entering air conditions** – 80°F Dry Bulb and 67°F Wet Bulb

Capacity based on 80°F EDB, 67°F EWB, 45°F Entering Water, 70 GPM

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<th>Model SSCBL</th>
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- 1 m³/s = 2120 cfm
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- 1 ton cooling = 1/12 mbh
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- (*F-32) 5/9 = °C
- 1 in wc = 249 pascals
- 1 lb = 0.45 kg

**NOTES:**

1. Coil Performance Data certified in accordance with ARI Standard 410
2. Maximum recommended coil face velocity is 550 sfpm
3. Consult your Sales Representative for special coil requirements
### COOLING PERFORMANCE TABLES (cont’d)

**Performance based on entering air conditions – 95°F Dry Bulb and 75°F Wet Bulb**

Capacity based on 95°F EDB, 75°F EWB, 45°F Entering Water, 70 GPM

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<tr>
<th>Furnace Models</th>
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- 1 lb = 0.45 kg

### NOTES:
1) Coil Performance Data certified in accordance with ARI Standard 410
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## Performance based on entering air conditions – 95°F Dry Bulb and 75°F Wet Bulb

Capacity based on 95°F EDB, 75°F EWB, 45°F Entering Water, 70 GPM

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**NOTES:**
1) Coil Performance Data certified in accordance with ARI Standard 410
2) Maximum recommended coil face velocity is 550 sfpm
3) Consult your Sales Representative for special coil requirements

### Coil Selection Requirements

**A. Required Application Information**
- For any coil selection the following information is required:
  - Cabinet option number based on the furnace model. (See the Cabinet Option Designations)
  - Airflow in standard cubic feet per minute (scfm). (For conversion from actual to standard see Conversion to Standard Airflow)
- **Airflow:**
  - Conditions (DB/WB) temperatures entering the coil
  - Cooling capacity requirements in MBH or Tons

**B. Required Chilled Water Coil Information**
- For water coils the following additional information must be supplied:
  - Entering fluid temperature, °F
  - Leaving fluid temperature, °F or fluid flow rate in gallons per minute (gpm)
  - Percentage of glycol and type (ethylene or propylene glycol)
- **Note:** For water coil applications where temperatures may fall below 32°F, coils should be drained per standard maintenance procedures. If a glycol is used, always test the glycol percentage prior to winter months to ensure adequate protection against freezing.
  - Maximum allowable fluid-side pressure drop through the coil, (ft w.c.)
C. Required Refrigerant Coil Information

For refrigerant coils the following additional information must be supplied:

- Evaporator temperature, °F
- Liquid temperature, °F
- Consult the factory for special circuiting or refrigerants

D. Special Requirements

The following special options are available on all coil types and sizes.

- Phenolic coatings
- Stainless steel coil casing material
- Copper fins

Note: For special requirements not listed here, contact your Reznor Sales Representative.

E. Entering Air Conditions

Design dry bulb and wet bulb temperatures must be considered when choosing a coil. For applications using a percentage of outdoor air, the condition of the “mixed air” entering the coil can be calculated as shown in the following steps.

- Mixed Dry Bulb Temperature

The mixed dry bulb temperature is a simple arithmetic average of the return and outside air temperatures weighted by the percentage of the standard cfm in each air stream.

Example:

1000 acfm of outside air @ 75°F (db) is mixed with 5000 acfm of return air @ 80°F (db). The elevation is 2000 ft. above sea level.

Step 1

Determine the standard airflow (scfm) by adjusting the actual (acfm) with correction factors for temperature (FT), or elevation (FE), or both (F = FT + FE).

Correction Factors for Outside Air --

- \( F_t = 0.05 \) and \( F_e = 0.08 \)
- Standard airflow = acfm / (1 + F_t + F_e) = 1000 / 1.13 = 885 scfm

Correction Factors for Return Air --

- \( F_t = 0.02 \) and \( F_e = 0.08 \)
- Standard airflow = acfm / (1 + F_t + F_e) = 5000 / 1.10 = 4545 scfm

Total supply airflow = 885 + 4545 = 5430 scfm

Step 2

The mixed air dry bulb temperature is the average as shown below.

- \( \frac{(95 \times 885) + (80 \times 4545)}{5430} = 82.4°F \)
- Mixed Wet Bulb Temperature

The mixed wet bulb temperature must be determined using a psychrometric chart.

Example

1000 acfm of outside air @ 75°F (wb) is mixed with 5000 acfm of return air @ 67°F (wb).

Step 1

Using Table 12, determine the enthalpy of each air stream.

- Outside air at 75°F (wb) = 38.6 Btu/lb
- Return air at 67°F (wb) = 31.6 Btu/lb

Step 2

The enthalpy of the mixed airstream is determined by calculating the average as shown below.

- \( \frac{(38.6 \times 885) + (31.6 \times 4545)}{5430} = 32.7 \text{ Btu/lb} \)

Step 3

The mixed airstream wet bulb temperature can be found in Table 12 corresponding to the mixed enthalpy value of 32.7 Btu/lb.

- \( T (\text{wb}) = 68.3°F \)
- Entering Air Condition

Entering air condition is typically written as T(db) / T(wb). In the above example, the mixed air condition is 82.4°F / 68.3°F.

F. Conversion to Standard Airflow

A fan must be selected using airflow calculated at the actual conditions of operation. Since a fan is a “constant volume” device, the actual CFM (ACFM) is required for analysis and properly determining motor requirements. To specify a coil, it is important that the airflow be converted into standard CFM (SCFM) or air at a density of 0.075 lb/ft³. Cooling and heating coils must be selected using SCFM. Up to an altitude of approximately 1,500 feet above sea level, very little error is introduced if ACFM is substituted in the selection of a coil. For altitudes that exceed 1,500 feet above sea level, the coil should always be selected using SCFM. The relationship between ACFM and SCFM is shown by the following equation: SCFM = ACFM x (Actual Density / 0.075). From this equation it is obvious that the relationship between SCFM and ACFM is dependent upon air density which is a function of blower temperature and elevation. Tables 10 and 11 contain correction factors for conversion from ACFM to SCFM.

The factors are used in the following manner: SCFM = ACFM x (1+F) where F may be a correction factor for temperature (F_t), or elevation (F_e), or both (F_t + F_e).

Example: A cooling coil must be selected for an application that is 3,500 ft. above sea level with entering air of 90°F dry bulb. The blower delivers 10,000 ACFM. What is the SCFM seen by the coil?

Answer: For 90°F the temperature correction factor in Table 10 is 0.04. At 3,500 feet, the elevation correction factor from Table 11 is 0.14. The answer is found by adding the two correction factors and dividing as shown here.

- SCFM = 10,000 ACFM / (1+0.14+0.04) = 8,475 SCFM

Temperature Correction Factors

<table>
<thead>
<tr>
<th>Temperature, °F</th>
<th>FT</th>
<th>FE</th>
</tr>
</thead>
<tbody>
<tr>
<td>00</td>
<td>-40</td>
<td>-0.21</td>
</tr>
<tr>
<td>05</td>
<td>-35</td>
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<td>10</td>
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<td>30</td>
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<td>5</td>
<td>0.06</td>
</tr>
<tr>
<td>50</td>
<td>10</td>
<td>0.08</td>
</tr>
</tbody>
</table>

Note: Standard temperature is 70°F.

Elevation Correction Factors

<table>
<thead>
<tr>
<th>Elevation, Ft.</th>
<th>FE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,500</td>
<td>0.06</td>
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<tr>
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<td>2,500</td>
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<td>3,000</td>
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<tr>
<td>4,500</td>
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<tr>
<td>5,000</td>
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<td>6,000</td>
<td>0.25</td>
</tr>
<tr>
<td>7,000</td>
<td>0.30</td>
</tr>
</tbody>
</table>

Note: Applications for elevations below 1,500 ft. do not require the use of an elevation correction factor.
Description

Reznor air handling units have a wide selection of factory installed custom designed DX and Chilled Water coils tailor made to the application, from 100% outside air in severe climates to 100% return air in mild climates. Coil application is designed by Reznor Software such as RezQuote™ or RezPro® Toolbox. The performance data is in compliance with ARI Standard 410. Design/Performance Data Sheets are generated by the software or are available from your Reznor Representative by submitting the Request Form found later in this catalog.

The double wall insulated draw-through coil cabinet is factory assembled to the system blower cabinet. Both DX and Chilled Water Coil cabinets are available. Both sides of the cooling coil section have easily removable door panels for routine coil inspection and cleaning. The removable stainless steel drain pan has an exterior 1" NPT connection.

Primary considerations are:
1) Sizing the air handler unit to meet both heating and cooling requirements.
2) Deciding on condenser capacity and staging.
3) Specifying cooling controls

Approximate cooling airflow ranges and capacity ranges (sea level at 45° suction and 45° chilled water) are shown in the DX and Chilled Water Performance Range Tables. Somewhat higher or lower capacities will result from changes in elevation, operating temperatures, flow rates, etc.

Cooling Coil Module Options

<table>
<thead>
<tr>
<th>DX Coil and dH Coil</th>
<th>Single Circuit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Circuiting</td>
<td>50-50 Dual Circuit</td>
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<tr>
<td></td>
<td>1/3 - 2/3 Split Circuit</td>
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<tr>
<td>Coil Casing</td>
<td>Galvanized Steel</td>
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<tr>
<td></td>
<td>Stainless Steel</td>
</tr>
<tr>
<td>Refrigerant Options</td>
<td>R22, R134a, R407c, R410a</td>
</tr>
<tr>
<td>Filters</td>
<td>1&quot;, 2&quot;, or 4&quot; Pleated</td>
</tr>
<tr>
<td></td>
<td>1&quot; Permanent</td>
</tr>
<tr>
<td></td>
<td>1&quot; Disposable</td>
</tr>
<tr>
<td>Coil Material</td>
<td>Copper Tube with Aluminum Fins</td>
</tr>
<tr>
<td></td>
<td>Copper Tube with Copper Fins</td>
</tr>
<tr>
<td>Coil Coating</td>
<td>ElectroFin™ Polymeric Coating</td>
</tr>
<tr>
<td>Cabinet</td>
<td>Double wall w/ insulation</td>
</tr>
<tr>
<td></td>
<td>Double wall with high density insulation</td>
</tr>
</tbody>
</table>

*ElectroFin™ is a registered trademark of AST ElectroFin, Inc.*

**NOTE:** To select the correct coil, you (or your Reznor Representative) must run the Reznor Coil Selection Software Program.
COIL SELECTION SOFTWARE

The Reznor Coil Selection Software (DX selection, shown above) that is part of RezQuote™ and RezPro® Toolbox packages will optimally design heating and cooling coils for your specific application for all Reznor models utilizing custom coils.

Exact design and performance are shown on coil data sheets output by Reznor coil selection software. You may request or download a copy of the software or submit the coil request form (found at the end of this section on cooling) to your Reznor Representative, who can then provide you with a detailed coil run.

DX Coils are available for one, two, or three stage operation. Two or three stage operation is generally recommended for makeup air, where the load on the coil may vary considerably.

Two stage DX cooling operation is accomplished by two equal capacity interlaced coil circuits for connection to a two stage condensing unit or two equal capacity single stage condensers. Three stage operation is accomplished by two unequal interlaced circuits, with approximately 1/3 of the coil tubes on the first circuit and 2/3 of the coil tubes on the second. Two condensing units of unequal capacity are used – one 5 ton and one 10 ton for example. The first circuit is connected to the smaller condenser and the second to the larger. The 3 stage digital cooling control system in the unit will activate the first condenser on first stage. On second stage, the first condenser is deactivated and the larger second condenser is activated. On third stage, both condensers are activated. TXV’s, liquid line solenoids, any desired hot gas bypass valves, and condensing units are provided by others. Alternate analog heating controls are available for cooling controls by others or heating/cooling by room thermostat only. Call your Reznor Representative for special requirements.

DX Coil Controls and Circuits

Individual coils are custom designed and internally circuited by Reznor coil selection/design software to optimize for the exact conditions specified. Variables are:

- Refrigerants: R410a
- Rows: 2, 3, 4, or 6
- Fins per Inch: 8, 10, 12, or 14
- Tube OD: 1/2” (standard) or 3/8” (low load)
- Fin Height: 20”, 22.5”, or 25” (75 to 150 sizes) 30”, 32.5”, or 35” (175 to 400A sizes)

Internal Circuited: The number of internal coil circuits is thermodynamically optimized, but circuits may be increased to decrease refrigerant pressure drop or decreased to increase refrigerant velocity. Refrigerant velocity should be above 1000 fpm and refrigerant pressure drop should be less than 8 psi. When coil loads are light and refrigerant velocity would be less than 1100 fpm with 1/2” tube, 3/8” tube is used to improve refrigerant velocity. Note that higher refrigerant velocities are available with 20”, 25”, 30” and 35” height coils and lower refrigerant pressure drop with optimal thermodynamic efficiency are available with 22.5” and 32.5” height coils (due to internal circulating). In general, preference is given to coils having the lowest air pressure drop, which favors taller fin heights.

Chilled Water Coils

Individual coils are custom designed and internally circuited by Reznor coil selection/design software to optimize for the exact conditions specified. Variables are:

- Refrigerants: Water, Ethylene Glycol(%), or Propylene Glycol(%)
- Rows: 4 or 6
- Fins per Inch: 6, 8, 10, 12, or 14
- Tube OD: 1/2

Internal Circuited: Quarter, Half, Three Quarter, or Single serpentine

Quarter circuit coils are used for low flow rates and have high pressure drops. Full circuit coils are for high flow rates and have low pressure drops. Half and Three Quarter circuit coils are in between. The best circuiting for a given application can be optimized based on flow rate, pressure drop and output requirements.

Chilled water coil performance is significantly diminished by glycol, higher percentages causing lower performance. The unit size/coil face may have to be increased to achieve adequate cooling performance with glycol in some cases. See approximate derates in the table below:

<table>
<thead>
<tr>
<th>Glycol Type</th>
<th>% Glycol by Wt</th>
<th>12%</th>
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<th>36%</th>
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</thead>
<tbody>
<tr>
<td>Ethylene</td>
<td>Derate</td>
<td>2.7%</td>
<td>4.2%</td>
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<td></td>
<td>Freezing Point ºF</td>
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</tr>
<tr>
<td>Propylene</td>
<td>Derate</td>
<td>3.9%</td>
<td>7.0%</td>
<td>13.6%</td>
<td>22.9%</td>
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<td>24.9</td>
<td>19.2</td>
<td>2.2</td>
<td>0.8</td>
<td>-6.0</td>
</tr>
</tbody>
</table>
MODEL SSCBL
INDOOR HEATING AND MAKEUP AIR UNITS
(SEPARATED COMBUSTION)

GENERAL
Provide packaged heating and makeup air unit as Reznor® brand equipment. These units shall be the SSCBL series with power-vented separated combustion 80% thermal efficient gas furnaces, arranged for suspension or mounting on a (slab) (post and rail).

CABINET
The (single-wall) (double-wall) insulated blower cabinet (and coil cabinet) is (are) to be arranged for (recirculated) (makeup) (combination recirculated and makeup) air. Inlet air shall be supplied through (horizontal cabinet opening) (outdoor cabinet with bottom inlet opening) (cabinet with both horizontal and bottom air inlet openings) (100% outside air damper with motor) (modulating outside air and return air mixing dampers) (alternating 100% outside air or 100% return air with 2-position damper motor) (modulating 100% outside air and 100% return air mixing damper with remote manual dial [potentiometer]) (100% outside air and 100% return air dampers with modulating motor controlled by pressure null switch) (modulating 100% outside air and 100% return air mixing damper with DDC control).

BLOWER
The units are to include a centrifugal blower and filter rack with (2" disposable) (2" permanent) (2" pleated) filters, factory installed. Motor shall be (open drip-proof) (totally enclosed) and motors should meet EISA specifications for efficiency with (adjustable belt drive) (variable frequency drive with (soft start) (2-speed) (DDC signal from remote device) (other) control). Include all other required controls.

HEATING CONTROLS
All units shall be equipped for use with (natural) (propane) gas, (120/1) (208/1) (208/3) (230/1) (230/3) (460/3) (575/3) supply voltage, 24-volt control transformer, automatic power venter, (motor contactor) (motor starter), and a(n) intermittent spark pilot (intertmittent spark pilot with timed lockout). Unit shall have a(n) (one-stage gas control [with relays] [with thermostat]) (two-stage gas control [with relays] [with thermostat]) (electronic modulation - 50%-100% turndown - gas control) (two-stage gas control from ductstat per furnace section) (electronic two-stage gas control using ductstat with remote temperature adjustment [and temperature display] per furnace section) (two-stage gas control for dual furnace units [using a ductstat with remote temperature adjustment [and temperature display]]) (three-stage gas control for triple furnace units) (electronic three-stage gas control using a ductstat with remote temperature selector [and temperature display]) (electronic modulation 50%-100% turndown - with ductstat and remote temperature selector) (electronic modulation with DDC controls) (electronic modulation gas control with four to one turndown ratio and remote temperature selector).

HEAT EXCHANGER
The gas furnace shall contain a heat exchanger of (aluminized) (E-3 [409] stainless) steel, die-formed burners of (aluminized) (E-3 [409] stainless) steel, and an (aluminized) (E-3 [409] stainless) steel drip pan. The furnace(s) shall be equipped with all required safety and limit controls.

OPTIONAL ACCESSORIES
The following accessories shall be provided: (convenience outlet), (air proving switch), (high ambient burner cutoff), (firestat[s]), (freezestat), (summer/winter control), (remote console with required lights and switches) (high and low gas pressure switches), (evaporative cooler), (double wall cabinet construction) (cooling coil cabinet with [DX] [chilled water] coil).

CERTIFICATION
The duct furnace and the packaged heating and makeup air system shall be design-certified to ANSI and CSA Standards.
Manufacturer must have minimum of forty (40) years of experience with this type of makeup air heating equipment. See drawings and schedules for quantities, sizes and capacities.
MODEL RPBL

ROOF MOUNTED HEATING AND MAKEUP AIR UNITS (POWER-VENTED)

GENERAL
Provide packaged, roof-mounted heating and make up air units as Reznor® brand equipment. These units shall be the RPBL series designed for 80% thermal efficiency with power-vented gas furnaces, arranged for roof mounting on a (field-assembled curb) (slab) (post and rail). The units are to be arranged for field duct connection with horizontal (downturn plenum) supply connection at discharge and horizontal (and/or bottom) inlet connection.

CABINET
The single (double) wall insulated blower cabinet (and coil cabinet) is (are) to be arranged for (recirculated) (makeup) (combination recirculated and makeup) air. Inlet air shall be supplied through (horizontal cabinet opening) (bottom inlet opening) (both horizontal and bottom air inlet openings with manual dampers - 30% outside air) (both horizontal and bottom air inlet openings with motorized dampers - 30% outside air) (100% outside air damper with damper motor - on/off) (modulating outside air and return air mixing dampers) (alternating 100% outside air or 100% return air with 2-position damper motor) (modulating 100% outside air and 100% return air mixing damper with remote manual dial [potentiometer]) (modulating 100% outside air and 100% return air mixing damper with DDC control). (Outside air hood with moisture eliminator louvers to be shipped separately.)

BLOWER
The units are to include a centrifugal blower and filter rack with (2" disposable) (2" permanent) (2" pleated) filters, factory installed. Motor shall be (open drip-proof) (totally enclosed) and motors shall meet EISA specifications for efficiency with (adjustable belt drive) (variable frequency drive with (soft start) (2-speed) (DDC signal from remote device) (other) control). Include all other required controls.

HEATING CONTROLS
All units shall be equipped for use with (natural) (propane) gas (208/1) (208/3) (230/3) (460/3) (575/3) supply voltage, 24-volt control transformer, automatic power venter, (motor contactor) (motor starter), (intermittent spark pilot [with timed lockout]), and a (one-stage) (two-stage [from ductstat]) (electronic two-stage using ductstat [with remote temperature adjustment]) [with remote temperature adjustment and temperature display]) (three-stage) (electronic three-stage using ductstat with remote temperature adjustment [and temperature display]) (electronic modulation with DDC controls) (electronic modulation gas control with four to one turndown ratio and remote temperature selector) (electronic modulation with 2:1 or 4:1 turndown ration) gas control system.

HEAT EXCHANGER
The gas furnace(s) shall contain a heat exchanger of (aluminized) (E-3 [409] stainless) steel, die-formed burners of (aluminized) (E-3 [409] stainless) steel, and an (aluminized) (E-3 [409] stainless) steel drip pan.

OPTIONAL ACCESSORIES
The following accessories shall be provided: (convenience outlet), (air proving switch), (high ambient burner cutoff), (firestat[s]), (freezeast), (summer/winter control), (remote console with required lights and switches), (high and low gas pressure switches), (outside air screened hood with moisture-eliminating louvers), (evaporative cooler), (downturn plenum), (double wall cabinet construction), (2-position discharge damper).

CERTIFICATION
All gas-fired packaged heating equipment must bear the C.S.A. label. The manufacturer must have a minimum of forty (40) years experience with this type of makeup air heating equipment.

Unit shall be warranted for 12 months from date of installation or 18 months from date of shipment, whichever occurs first.

See drawings and schedules for quantities, sizes and capacities.
MODEL RBL

OUTDOOR MOUNTED CABINET BLOWER

GENERAL
Provide roof-mounted cabinet blower, air handler units as Reznor® brand equipment. These units shall be Model RBL, arranged for roof mounting on a (field-assembled curb) (slab) (post and rail). The units are to be arranged for field duct connection with horizontal (downturn plenum) supply connection at discharge and horizontal (and/or bottom) inlet connection.

CABINET
The single (double) wall insulated blower cabinet (and coil cabinet) is (are) to be arranged for (recirculated) (makeup) (combination recirculated and makeup) air. Inlet air shall be supplied through (horizontal cabinet opening) (bottom inlet opening) (both horizontal and bottom air inlet openings) (both horizontal and bottom air inlet openings with manual dampers - 30% outside air) (both horizontal and bottom air inlet openings with motorized dampers - 30% outside air) (100% outside air damper with damper motor - on/off) (modulating outside air and return air mixing dampers) (alternating 100% outside air or 100% return air with 2-position damper motor) (modulating 100% outside air and 100% return air mixing damper with remote manual dial [potentiometer]) (modulating 100% outside air and 100% return air mixing damper with DDC control). (Outside air hood with moisture eliminator louvers to be shipped separately.)

BLOWER
The units are to include a centrifugal blower, (open drip-proof) (totally enclosed) blower motor, and an adjustable belt drive, filter (rack with 2” [disposable] [permanent] [pleated] filters, factory installed). Include all required controls, dampers, and inlets to provide an air control cycle of (100% outside air inlet and 100% return air inlet with dampers and [manual dial/potentiometer] [2-position motor] [modulating damper motor and mixed air controller]) (30% outdoor air inlet, hood [with manual locking damper] [with motorized damper] and bottom inlet).

OPTIONAL ACCESSORIES
The following accessories shall be provided: (summer/winter control), (outside air screened hood with moisture-eliminating louvers), (evaporative cooler), (downturn plenum), (double wall cabinet construction), (2-position discharge damper).

CERTIFICATION
The manufacturer must have a minimum of forty (40) years experience with this type of air handling equipment. Unit shall be warranted for 12 months from date of installation or 18 months from date of shipment, whichever occurs first.
See drawings and schedules for quantities, sizes and capacities.
**LIMITED WARRANTY**

Manufacturer warrants to the original owner-user that this Reznor product will be free from defects in material or workmanship. This warranty is limited to twelve (12) months from the date of original installation, whether or not actual use begins on that date, or eighteen (18) months from date of shipment, whichever occurs first.

**OPTIONAL PURCHASED EXTENDED WARRANTY**

Models RPBL and SSCBL — **Option XW2** - Extended four (4) years for a total five-year, non-prorated warranty on the heat exchanger. — **Option XW3** - Extended nine (9) years for a total ten-year, non-prorated warranty on the heat exchanger.

**LIMITATIONS AND EXCLUSIONS**

Manufacturer’s obligations under this warranty and the sole remedy for its breach are limited to repair, at its manufacturing facility, of any part or parts of its Reznor products which prove to be defective; or, in its sole discretion, replacement of such products. All returns of defective parts or products must include the product model number and serial number, and must be made through an authorized Reznor distributor or arranged through Reznor Customer Service. Authorized returns must be shipped prepaid. Repaired or replacement parts will be shipped F.O.B. shipping point.

1. The warranty provided herein does not cover charges for labor or other costs incurred in the troubleshooting, repair, removal, installation, service or handling of parts or complete products.

2. All claims under the warranty provided herein must be made within ninety (90) days from the date of discovery of the defect. Failure to notify manufacturer of a warranted defect within ninety (90) days of its discovery voids obligations hereunder.

3. The warranty provided herein shall be void and of no effect in the event that (a) the product has been operated outside its designed output capacity (heating, cooling, airflow); (b) the product has been subjected to misuse, neglect, accident, improper or inadequate maintenance, corrosive environments, environments containing airborne contaminants (silicone, aluminum oxide, etc.), or excessive thermal shock; (c) unauthorized modifications are made to the product; (d) the product is not installed or operated in compliance with the manufacturer’s printed instructions; (e) the product is not installed and operated in compliance with applicable building, mechanical, plumbing and electrical codes; or (f) the serial number of the product has been altered, defaced or removed.

4. The warranty provided herein is for repair or replacement only. Manufacturer shall not be liable for any loss, cost, damage, or expense of any kind arising out of a breach of the warranty. Further, manufacturer shall not be liable for any incidental, consequential, exemplary, special, or punitive damages, nor for any loss of revenue, profit or use, arising out of a breach of this warranty or in connection with the sale, maintenance, use, operation or repair of any Reznor product. In no event will manufacturer be liable for any amount greater than the purchase price of a defective product. The disclaimers of liability included in this paragraph 4 shall remain in effect and shall continue to be enforceable in the event that any remedy herein shall fail of its essential purpose.

5. **THIS WARRANTY IS THE SOLE AND EXCLUSIVE WARRANTY FOR REZNOR PRODUCTS, AND IS IN LIEU OF ALL OTHER EXPRESS AND IMPLIED WARRANTIES. MANUFACTURER SPECIFICALLY DISCLAIMS ALL OTHER EXPRESS AND IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, ALL IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.** No person or entity is authorized to bind manufacturer to any other warranty, obligation or liability for any Reznor product. Installation, operation or use of the Reznor product for which this warranty is issued shall constitute acceptance of the terms hereof.
Reznor® is your global source for heating, ventilating and air conditioning equipment.

For more information on Reznor HVAC Equipment, contact your local Reznor Representative by calling 800-695-1901.
Or, find us on the internet at www.ReznorHVAC.com

In keeping with our policy of continuous product improvement, we reserve the right to alter, at any time, the design, construction, dimensions, weights, etc., of equipment information shown here.
Enthalpy of Saturated Air for Various Wet Bulb Temperatures

<table>
<thead>
<tr>
<th>Wet Bulb Temp, [deg.F]</th>
<th>Enthalpy, [Btu / lb]</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>20.4</td>
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<td>50.5</td>
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<td>51</td>
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<th>Enthalpy, [Btu / lb]</th>
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<td>57.5</td>
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<th>Wet Bulb Temp, [deg.F]</th>
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<th>Enthalpy, [Btu / lb]</th>
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**General Note:** Enthalpy is approximately constant with constant wet bulb temperature. There is a slight variation with dry bulb temperature, but the variation is typically negligible over the range of dry bulb temperatures common to HVAC applications.
Use this chart to determine whether a particular voltage/horsepower combination is available. Option AN10 starter must be ordered where indicated. 1-3 HP Open and Enclosed motors that require a starter do not have internal overload protection, and a starter (Option AN10) must be ordered to provide external overload protection. 1-3 HP Open and Enclosed motors that do not require a starter have internal overload protection and a standard contactor.

In the chart to the right, “S” indicates that a motor starter is standard, “C” indicates that the Contactor is standard and a motor starter is optional, “SV” indicates that an optional motor starter or a variable frequency drive must be selected.

<table>
<thead>
<tr>
<th>Motor Type</th>
<th>Option No.</th>
<th>HP</th>
<th>Voltage RPM</th>
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<th>208/3/60 AK5</th>
<th>230/3/60 AK6</th>
<th>460/3/60 AK7</th>
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<td>C</td>
<td>C</td>
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<tr>
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<td>C</td>
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<td>1800</td>
<td>C</td>
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<td>C</td>
<td>C</td>
<td>C</td>
<td>SV</td>
</tr>
<tr>
<td></td>
<td>AL9</td>
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</table>
Use this chart to determine whether a particular voltage/horsepower combination is available. Option AN10 starter must be ordered where indicated. 1-3 HP Open and Enclosed motors that require a starter do not have internal overload protection, and a starter (Option AN10) must be ordered to provide external overload protection. 1-3 HP Open and Enclosed motors that do not require a starter have internal overload protection and a standard contactor.

In the chart to the right, “S” indicates that a motor starter is standard, “C” indicates that the Contactor is standard and a motor starter is optional, “SV” indicates that an optional motor starter or a variable frequency drive must be selected.

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<th>Motor Type</th>
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### Roof Curb Dimensions for Model RPB

#### Option CJ1 - Roof Curb for Heater Only

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<th>B (in.)</th>
<th>C* (in.)</th>
<th>D* (in.)</th>
<th>G (in.)</th>
<th>H (in.)</th>
<th>J (in.)</th>
<th>Weight (lbs)</th>
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#### Option CJ2 - Roof Curb for Heater Plus Factory-Installed Downturn Plenum (Option AQ5 or AQ8)

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<th>J (in.)</th>
<th>Weight (lbs)</th>
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* C and D are roof opening dimensions
MOTOR FULL LOAD AMPS (F.L.A.) TABLES

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Motor
Type
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TEFC

Motor
F.L.A.
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2.1
2.3
1.1
1.4
0.75
3.6
2.2
1.9
1.6
1.4
0.7
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1.4
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RPM
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Motor
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Motor
F.L.A.
13
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2.6
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RPM
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# MOTOR FULL LOAD AMPS (F.L.A.) TABLES (cont’d)

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<td>EE</td>
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<td>1750</td>
<td>575</td>
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</table>
A Reznor remote console is designed to allow remote control of the system as well as provide indicator safety lights. The console is comprised of a 16-gauge steel box with knockouts for field wiring, wiring terminal blocks suited to components, and a custom engraved plastic cover. The engraved lettering on the cover indicates the function and position of the switch and the message of the indicator light. The box may be either recessed or wall mounted. A mounted ring is included for wall mounting. In place of the standard plastic cover, an optional stainless steel cover is available (requires extended lead time).

The remote console option is available with twelve pre-selected combinations of factory-installed switches, indicator lights and controls. The available combinations of components are illustrated below. Each of the consoles may be ordered with one additional factory-mounted control. Controls available are a one- or two-stage heating thermostat, a one- two-stage heating/cooling thermostat, or a Maxitrol Temperature Selector. If the installation requires any components or component combinations that are not available with Options RC1-12, it is necessary to specify a custom-built remote console (see Remote Console Section).
### Remote Console

#### Optional on Indirect Fired Packaged Heating/Makeup Air Systems (cont’d)

**Option RC9**

<table>
<thead>
<tr>
<th><strong>Lights</strong></th>
<th><strong>Switch</strong></th>
<th><strong>Control</strong></th>
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<tbody>
<tr>
<td>Blower On</td>
<td>Summer/Off/Winter</td>
<td>Potentiometer*</td>
</tr>
<tr>
<td>Burner On</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cool On</td>
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<td></td>
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</table>

**Option RC10**

<table>
<thead>
<tr>
<th><strong>Lights</strong></th>
<th><strong>Switch</strong></th>
<th><strong>Control</strong></th>
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</thead>
<tbody>
<tr>
<td>Blower On</td>
<td>Summ/Wnter</td>
<td>Potentiometer*</td>
</tr>
<tr>
<td>Burner On</td>
<td></td>
<td></td>
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**Option RC11**

<table>
<thead>
<tr>
<th><strong>Lights</strong></th>
<th><strong>Switch</strong></th>
<th><strong>Control</strong></th>
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</thead>
<tbody>
<tr>
<td>Blower On</td>
<td>On/Off</td>
<td></td>
</tr>
<tr>
<td>Burner On</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cool On</td>
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</table>

**Option RC12**

<table>
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<th><strong>Lights</strong></th>
<th><strong>Switch</strong></th>
<th><strong>Control</strong></th>
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</thead>
<tbody>
<tr>
<td>Blower On</td>
<td>On/Off</td>
<td>Potentiometer*</td>
</tr>
<tr>
<td>Burner On</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cool On</td>
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</table>

*Must order Damper Arrangement Option GE10 to get a remote potentiometer (see Air Control System section).*

**NOTE:** To coordinate option selection, see Mixing Box Module and Air Inlet Options section for damper arrangement options and Heating and Heating/Cooling Controls section for control selection.

### Included Options

<table>
<thead>
<tr>
<th>Remote Console Component</th>
<th>Function</th>
<th>Minimum No. of Wires</th>
<th>Included Options</th>
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<tr>
<td>Blower On Indicator Light</td>
<td>Lights when blower is operating</td>
<td>X X X X X X X X X</td>
<td>RC1, RC2, RC3, RC4, RC5, RC6, RC7, RC8, RC9, RC10, RC11, RC12</td>
</tr>
<tr>
<td>Burner On Indicator Light</td>
<td>Lights when burners are lit</td>
<td>X X X X X X X X X</td>
<td>RC1, RC2, RC3, RC4, RC5, RC6, RC7, RC8, RC9, RC10, RC11, RC12</td>
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<tr>
<td>Dirty Filter Indicator Light</td>
<td>Lights when the pressure switch indicates that filters need to be cleaned or replaced</td>
<td>N/A X N/A X N/A X N/A X N/A N/A N/A X</td>
<td>RC1, RC2, RC3, RC4, RC5, RC6, RC7, RC8, RC9, RC10, RC11, RC12</td>
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<tr>
<td>On/Off Control Switch</td>
<td>“On” position energizes the unit for thermostat control</td>
<td>N/A N/A X X N/A N/A X N/A N/A X</td>
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<td>Summer/Winter/Off Control Switch</td>
<td>“Summer” position operates the blower only</td>
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</tr>
<tr>
<td>Heat/Vent/Cool System Switch</td>
<td>“Heat” position energizes the unit for thermostat control. “Vent” position operates the blower and opens automatically controlled outside air dampers</td>
<td>N/A N/A N/A N/A N/A N/A N/A N/A N/A N/A X N/A N/A X</td>
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<td>Cooling Indicator Light</td>
<td>Lights when the cooling system is operating</td>
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### Wires:

#### Minimum No. of Wires

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<tr>
<td>4 Lights</td>
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</table>

**NOTE:** For cooling light, add one wire.

- 1 DPDT (3-position) Switch: 4-6
- 1 SPDT Switch: 3
- 1 DPST Switch: 5
- 1 SPST Switch: 2
- 1 2-Stage Thermostat: 3-9
- 1 1-Stage Thermostat: 2-8
- 1 Potentiometer: 3

**CAUTION:** The minimum number of wires listed should be used only as a guideline. Do NOT use for actual wiring. The required number of wires varies depending upon the circuit and the function of the switch and can only be accurately determined from the wiring diagram designed for the specific installation.
THERMOSTATS FOR WALL OR CONSOLE MOUNTING
(If console mounted, select one per console)
Applies to Models RPB, RPBL, & SSCBL (unless otherwise noted)

Single Stage Heating/Cooling Thermostat - Option CL1

Non-programmable
24V Supply voltage
50° - 90°F
(Cross reference: P/N 255350)
(Applies to Model RPB only)

Electronic 2-Stage Heating/Cooling Thermostat (Wall Mount Option CL33, Console Mount Option RCT5 *)

7-Day programmable
LCD Display
24VAC/50/60 Hz Supply
Microprocessor Control
Selectable Output Staging:
1) 1 Heat — 1 Cool
2) 1 Heat — 2 Cool
3) 2 Heat — 1 Cool
4) 2 Heat — 2 Cool
Sub/Base has Auto/Cool/Off/Heat System switch and Auto/On (fan) Switch
(Cross reference: P/N 221038)
Use with Remote Consoles RC1, RC2 or RC9

Override Thermostat for Electronic Modulation - Option CL9

Low voltage room override thermostat
Electronic modulating
60-85°F
For use with makeup air applications
Vertical mounting
SPST
Line voltage
(Cross reference: P/N 24857)
Use with electronic modulating gas controls, Options AG8, AG9, AG39 or AG41

Electronic Single Stage Heating/Cooling Thermostat on Panel (Wall Mount Option CL52, Console Mount Option RCT9)

5 Day/2 Day Programmable
LCD Display
(battery required)
with Fan Auto/On and
Cool/Off/Heat Switches
(Cross reference: P/N 220632)
Use with Remote Consoles RC1, RC2 or RC9

Two Stage Heating/Cooling Thermostat - Option CL22

Non-programmable
24V Supply voltage
50° - 90°F
(Cross reference: P/N 220630)

Electronic Single Stage Heating/Cooling Thermostat - Option CL1

Non-programmable
24V Supply voltage
50° - 90°F
(Cross reference: P/N 255350)
(Applies to Model RPB only)

* RCT5 contains most switching functions that are likely to be needed. Any switches on the panel limit the number of lights and/or potentiometer that can be installed due to space limitations and affects control sequence. Consult your Reznor Representative.
REMOTE CONSOLE
OPTIONAL ON INDIRECT FIRED
PACKAGED HEATING/MAKEUP AIR SYSTEMS (cont’d)

If components or component combinations are required that are not included in the standard remote console option offering, select a custom-built remote console. Custom design the console by selecting from the light label, switch label, and control selections listed below. Specific functions of all switches and lights must be included on the order.

CUSTOM BUILT REMOTE MONITORING CONSOLE
DESCRIPTION

<table>
<thead>
<tr>
<th>Incident</th>
<th>EN/LOCATION</th>
<th>LIGHT LABEL</th>
<th>SWITCH LABEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>WALL MOUNTED</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RC1-RC10, RC12 without an optional control</td>
<td>10 3/4</td>
<td>273</td>
<td>7 5/8</td>
</tr>
<tr>
<td>RC-10 and RC12 with an optional control and RC11 with or without an optional control</td>
<td>15 3/4</td>
<td>400</td>
<td>7 5/8</td>
</tr>
<tr>
<td>RECESSED - Size of the body; do not use mounting ring</td>
<td>10 3/4</td>
<td>273</td>
<td>6 5/8</td>
</tr>
<tr>
<td>RC1-RC10, RC12 without an optional control</td>
<td>15 3/4</td>
<td>400</td>
<td>6 5/8</td>
</tr>
</tbody>
</table>

CUSTOM REMCON
Engraved Plastic Cover on Metal Box with Mounting Ring

<table>
<thead>
<tr>
<th>Lights Qty</th>
<th>Switches Qty (2 position or 3 position) Qty</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 3 4 2 3 4 2 3 4</td>
<td>0 0 0 1 1 1 2 2 2</td>
</tr>
</tbody>
</table>

Custom Plastic Cover (combinations or engraving not listed) - call Reznor Representative for approval and pricing.

LIGHT LABEL TO BE ENGRAVED ON PLASTIC COVER
(number of selections must agree with quantity of lights available on the REMCON model ordered)

<table>
<thead>
<tr>
<th>LIGHT LABEL</th>
<th>SWITCH LABEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>BURNER</td>
<td>EB1</td>
</tr>
<tr>
<td>BLOWER</td>
<td>EB2</td>
</tr>
<tr>
<td>DIRTY FILTER (LIGHT with SWITCH IN UNIT)</td>
<td>EB3</td>
</tr>
<tr>
<td>COOL</td>
<td>EB4</td>
</tr>
<tr>
<td>SAFETY LOCKOUT</td>
<td>EB21</td>
</tr>
<tr>
<td>Custom Label - 14 characters maximum</td>
<td>SPEC</td>
</tr>
<tr>
<td>SUMMER/OFF/WINTER</td>
<td>EB5A</td>
</tr>
<tr>
<td>HEAT/OFF/VENT</td>
<td>EB5B</td>
</tr>
<tr>
<td>ON/OFF/AUTO</td>
<td>EB5C</td>
</tr>
<tr>
<td>HEAT/VENT/COOL</td>
<td>EB5D</td>
</tr>
<tr>
<td>DAY/OFF/NIGHT</td>
<td>EB5E</td>
</tr>
<tr>
<td>OCCUPIED/OFF/UOCCUPIED</td>
<td>EB5F</td>
</tr>
<tr>
<td>LOCAL/OFF/REMOTE</td>
<td>EB5G</td>
</tr>
<tr>
<td>HIGH/HIGH/LOW</td>
<td>EB5H</td>
</tr>
<tr>
<td>HAND/OFF/AUTO</td>
<td>EB5I</td>
</tr>
<tr>
<td>HEAT/OFF/COOL</td>
<td>EB5J</td>
</tr>
<tr>
<td>HEAT/OFF/DRAIN</td>
<td>EB5K</td>
</tr>
<tr>
<td>ON/OFF (DPST System Switch)</td>
<td>EB6X</td>
</tr>
<tr>
<td>Custom Label - 22 characters maximum</td>
<td>SPEC</td>
</tr>
</tbody>
</table>

SWITCH LABELS TO BE ENGRAVED ON COVER
Select REMCON Size -C through -M based on number of lights and switches selected. Switches selected cannot have duplicate function.

<table>
<thead>
<tr>
<th>INCIDENT</th>
<th>LIGHT LABEL</th>
<th>SWITCH LABEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUMMER/OFF/WINTER</td>
<td>EB5A</td>
<td></td>
</tr>
<tr>
<td>HEAT/OFF/VENT</td>
<td>EB5B</td>
<td></td>
</tr>
<tr>
<td>ON/OFF/AUTO</td>
<td>EB5C</td>
<td></td>
</tr>
<tr>
<td>HEAT/VENT/COOL</td>
<td>EB5D</td>
<td></td>
</tr>
<tr>
<td>DAY/OFF/NIGHT</td>
<td>EB5E</td>
<td></td>
</tr>
<tr>
<td>OCCUPIED/OFF/UOCCUPIED</td>
<td>EB5F</td>
<td></td>
</tr>
<tr>
<td>LOCAL/OFF/REMOTE</td>
<td>EB5G</td>
<td></td>
</tr>
<tr>
<td>HIGH/HIGH/LOW</td>
<td>EB5H</td>
<td></td>
</tr>
<tr>
<td>HAND/OFF/AUTO</td>
<td>EB5I</td>
<td></td>
</tr>
<tr>
<td>HEAT/OFF/COOL</td>
<td>EB5J</td>
<td></td>
</tr>
<tr>
<td>HEAT/OFF/DRAIN</td>
<td>EB5K</td>
<td></td>
</tr>
<tr>
<td>ON/OFF (DPST System Switch)</td>
<td>EB6X</td>
<td></td>
</tr>
<tr>
<td>Custom Label - 22 characters maximum</td>
<td>SPEC</td>
<td></td>
</tr>
</tbody>
</table>
OPTIONAL CONTROLS MOUNTED ON CUSTOM REMCONS

<table>
<thead>
<tr>
<th>Description</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-Stage Heating Thermostat</td>
<td>RCT1</td>
</tr>
<tr>
<td>2-Stage Heating Thermostat</td>
<td>RCT2</td>
</tr>
<tr>
<td>1-Stage Heating/Cooling Thermostat</td>
<td>RCT3</td>
</tr>
<tr>
<td>2-Stage Heating/Cooling Thermostat</td>
<td>RCT4</td>
</tr>
<tr>
<td>Commercial Electronic Programmable Heating/Cooling Thermostat*</td>
<td>RCT5</td>
</tr>
<tr>
<td>T244 Selectrastat used with Gas Control Option AG33</td>
<td>RT6A</td>
</tr>
<tr>
<td>T107A-1 Selectrastat used with Option AG7</td>
<td>RT6B</td>
</tr>
<tr>
<td>Maxitrol T115 Room Override Thermostat (Gas Control Options AG8, AG9, or AG31)</td>
<td>RCT7</td>
</tr>
<tr>
<td>2-Stage Heating/Cooling Thermostat (same as Option CL50)</td>
<td>RCT8</td>
</tr>
<tr>
<td>Maxitrol TD-121 Dial (used with Gas Control Option AG9)</td>
<td>RCM1</td>
</tr>
<tr>
<td>Maxitrol TD-114 Dial (used with Gas Control Options AG30 and AG31 - U.S.)</td>
<td>RCM2</td>
</tr>
<tr>
<td>Maxitrol TD-114 Dial (used with Gas Control Options AG30 and AG31 - Canada)</td>
<td>RCM3</td>
</tr>
<tr>
<td>Maxitrol TD-114A Dial (used with Gas Control Option AG32)</td>
<td>RCM4</td>
</tr>
<tr>
<td>Maxitrol TD-114B Dial (used with Gas Control Option AG35)</td>
<td>RCM5</td>
</tr>
<tr>
<td>Maxitrol TD-92 (used with Gas Control Options AG39 and AG41)</td>
<td>RCM6</td>
</tr>
<tr>
<td>Potentiometer (used with Air Control Options AR18, AR19, AR22, or AR55)</td>
<td>RCD1</td>
</tr>
<tr>
<td>Mount other Control on Remcon (Call for Quote - may require relays)</td>
<td>SPEC</td>
</tr>
</tbody>
</table>

Number of Optional Controls Available by custom REMCON Model - length of console changes; see dimensions below

<table>
<thead>
<tr>
<th>Custom REMCON</th>
<th>- C -</th>
<th>- D -</th>
<th>- E -</th>
<th>- F -</th>
<th>- G -</th>
<th>- H -</th>
<th>- J -</th>
<th>- K -</th>
<th>- M -</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engraved Plastic Cover on Metal Lights Qty</td>
<td>Qty</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Box with Mounting Ring Switches (2 position or 3 position) Qty</td>
<td>Qty</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Maximum number of Optional Controls available</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Custom REMCON Dimensions</td>
<td>Without an optional control, the length of the console is 10-3/4&quot; (273mm). When an optional control is added to any custom console, length becomes 15-3/4&quot; (400mm). All consoles with mounting ring are 7-5/8&quot; (194mm) high and 2-5/8&quot; (67mm) deep. If recessed (not using mounting ring), box is 6-5/8&quot; (168mm) high.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* RCT5 contains most switching functions that are likely to be needed. Any switches on the panel limit the number of lights and/or potentiometer that can be installed due to space limitations and affects control sequence. Consult your Reznor Representative.

Location of Knockout Holes -
Dimensions to Center Line of all holes
Reznor® RPB Series packaged units are 80% thermal efficient, power-vented, gas-fired forced air furnaces, designed for installation outdoors and used with recirculating and/or makeup air warm air duct systems. These units use either natural or propane gas, as specified, in sizes from 125,000 through 400,000 BTUH gas input.

Standard features include a spark-ignited intermittent pilot and a single-stage, 24-volt gas valve. Each unit has all the required limit and safety controls including a venter pressure switch which verifies power vent flow prior to allowing operation of the gas valve. For automatic operation, each unit is wired for field connection to a remote 24-volt thermostat.

The RPB Series models have a weatherized galvalume steel cabinet with interlocking joint construction and a full curb cap for mounting on a roof curb or supports. The standard packaged furnace has a horizontal discharge air opening. A bottom discharge air opening is available with the addition of a downturn plenum. The blower cabinet has a standard horizontal inlet but is engineered to allow for horizontal and/or bottom air inlet with various optional damper control systems. The air control systems for both return air heating and makeup air are complemented by a selection of gas control options. To obtain the desired CFM, a wide selection of optional motor and drive combinations is available to operate the centrifugal blower.

To meet a variety of installation requirements, Model RPB packaged units are available in selected combinations equipped with a downturn plenum, an evaporative cooling module, a cooling coil cabinet with DX or chilled water coil, and/or an outside air inlet hood.

- Orifices for natural gas
- Aluminized steel heat exchanger (When inlet air temperature is below 40°F or temperature rise is less than 40°F, optional stainless steel heat exchanger is recommended)
- 120-volt power supply
- 24-volt control transformer
- Redundant single-stage combination gas valve (see Note 1)
- Intermittent spark pilot
- Fan and limit safety controls
- Power venter
- Reverse air flow limit control
- Adjustable belt drive
- Motor contactor
- Terminal block wiring
- Full curb cap base
- Horizontal discharge air opening with duct flanges
- Horizontal inlet air opening with duct flanges
- Left side access to burner and controls (facing airstream)
- Insulated, weatherized steel cabinet with interlocking joint construction for outdoor mounting
- 1/2” O.D. BX cable (Chicago code)

NOTE 1: Regulated combination redundant gas valve consists of combination pilot solenoid valve, electric gas valve, pilot filter, pressure regulator, pilot shut-off, and manual shut-off, all in one body. Gas supply pressure must not exceed 0.5 PSI (8 oz. - 14” W.C.). Minimum inlet pressure for natural gas is 5” W.C. Minimum inlet pressure for propane gas is 11” W.C.

NOTE 2: Not certified for residential use.
TECHNICAL DATA

MODEL RPB (cont’d)

- Unit equipped for propane gas
- E-3 (409) stainless steel heat exchanger
- E-3 (409) stainless steel burners
- E-3 (409) stainless steel drip pan
- Intermittent spark pilot with flame supervision and timed lockout
- 1/4 HP through 3 HP open drip-proof or totally enclosed motors, 5 HP available in open drip-proof motor only (motors meet EISA specifications for efficiency)
- 208/1, 230/1, 208/3, 230/3, 460/3, 575/3 alternate supply voltages
- Motor starter (optional with motors having internal overload protection)
- Burner air shutters (required for units equipped for propane gas)
- Two-stage gas control (unit mounted or remote temperature selector)
- Electronic modulation (50-100% turndown and 20-100% turndown)
- Direct digital control packages for system control
- Makeup air controls/dampers
- Convenience outlet
- Firestat(s)
- Freezestat
- Filter rack with filters (2" disposable, permanent or pleated)
- Evaporative cooling module
- 30% O/A inlet hood (adjustable 0-30% dampers)
- Downturn plenum cabinet (insulated)
- Discharge damper, 2-position, with downturn plenum
- Double wall cabinet construction
- High ambient burner cutoff
- Gas pressure safety switches
- Air flow proving switch
- Right side controls (facing airstream)

OPTIONAL FEATURES - FACTORY INSTALLED

- Full roof curb
- Disconnect switch - UL Listed
- Single-stage thermostat
- Two-stage thermostat
- Electronic 7-day programmable thermostat
- Thermostat guard with locking cover
- Remote control console
- 100% outside air, screened inlet air hood
- Vertical flue extension

OPTIONAL FEATURES - FIELD INSTALLED

- Vertical flue extension
- 100% outside air, screened inlet air hood
- Remote control console
- Air flow proving switch
- Right side controls (facing airstream)

### TECHNICAL DATA

<table>
<thead>
<tr>
<th>SIZE</th>
<th>Heating Input</th>
<th>Thermal Output Capacity (80%)</th>
<th>Unit Amps (Less motor) 115V</th>
<th>Control Amps (24V)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BTUH</td>
<td>(kW)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>125</td>
<td>125,000</td>
<td>(36.6)</td>
<td>1.9</td>
<td>0.95</td>
</tr>
<tr>
<td>150</td>
<td>150,000</td>
<td>(44.0)</td>
<td>1.9</td>
<td>0.95</td>
</tr>
<tr>
<td>175</td>
<td>175,000</td>
<td>(51.3)</td>
<td>1.9</td>
<td>0.95</td>
</tr>
<tr>
<td>200</td>
<td>200,000</td>
<td>(58.6)</td>
<td>1.9</td>
<td>0.95</td>
</tr>
<tr>
<td>225</td>
<td>225,000</td>
<td>(65.9)</td>
<td>1.9</td>
<td>0.95</td>
</tr>
<tr>
<td>250</td>
<td>250,000</td>
<td>(73.3)</td>
<td>1.9</td>
<td>0.95</td>
</tr>
<tr>
<td>300</td>
<td>300,000</td>
<td>(87.9)</td>
<td>1.9</td>
<td>0.95</td>
</tr>
<tr>
<td>350</td>
<td>350,000</td>
<td>(102.6)</td>
<td>1.9</td>
<td>0.95</td>
</tr>
<tr>
<td>400</td>
<td>400,000</td>
<td>(117.2)</td>
<td>1.9</td>
<td>0.95</td>
</tr>
</tbody>
</table>

### Optional Features - Factory Installed

- Intermittent spark pilot with flame supervision and timed lockout
- 1/4 HP through 3 HP open drip-proof or totally enclosed motors, 5 HP available in open drip-proof motor only (motors meet EISA specifications for efficiency)
- 208/1, 230/1, 208/3, 230/3, 460/3, 575/3 alternate supply voltages
- Motor starter (optional with motors having internal overload protection)
- Burner air shutters (required for units equipped for propane gas)
- Two-stage gas control (unit mounted or remote temperature selector)
- Electronic modulation (50-100% turndown and 20-100% turndown)
- Direct digital control packages for system control
- Makeup air controls/dampers
- Convenience outlet
- Firestat(s)
- Freezestat
- Filter rack with filters (2" disposable, permanent or pleated)
- Evaporative cooling module
- 30% O/A inlet hood (adjustable 0-30% dampers)
- Downturn plenum cabinet (insulated)
- Discharge damper, 2-position, with downturn plenum
- Double wall cabinet construction
- High ambient burner cutoff
- Gas pressure safety switches
- Air flow proving switch
- Right side controls (facing airstream)

### Optional Features - Field Installed

- Full roof curb
- Disconnect switch - UL Listed
- Single-stage thermostat
- Two-stage thermostat
- Electronic 7-day programmable thermostat
- Thermostat guard with locking cover
- Remote control console
- 100% outside air, screened inlet air hood
- Vertical flue extension

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*In the U.S. ratings are for altitudes to 2000 feet. Above 2000 feet derate by orifice change, 4% for each 1000 feet above sea level.

In Canada ratings are for altitudes to 2000 feet. High altitude units (2001 to 4500 ft.) are derated by 10% of maximum input.

Prefix "H" indicates high CFM units without directional finger baffles.

Weights shown are for packaged furnace and blower. For weights of accessories, see below.

Add to base weight of unit. For weights for other options such as the cooling coil cabinet or roof curbs, see those sections.

Gas connection for optional propane is 1/2" for all sizes. Sizes shown are for gas connection to single stage gas valve, NOT gas supply line size.
**Weights of Accessories - add to unit Ship Weight**

Weights of options shipped installed on the furnace:

<table>
<thead>
<tr>
<th></th>
<th>75, 100, 125</th>
<th>150, 175</th>
<th>200, 225</th>
<th>250, 300</th>
<th>350</th>
<th>400</th>
</tr>
</thead>
<tbody>
<tr>
<td>AQ5</td>
<td>lbs.</td>
<td>166</td>
<td>177</td>
<td>196</td>
<td>229</td>
<td>253</td>
</tr>
<tr>
<td></td>
<td>(kg)</td>
<td>(75)</td>
<td>(80)</td>
<td>(89)</td>
<td>(104)</td>
<td>(115)</td>
</tr>
</tbody>
</table>

Weights of options shipped separately for field assembly and installation:

<table>
<thead>
<tr>
<th></th>
<th>75, 100, 125</th>
<th>150, 175</th>
<th>200, 225</th>
<th>250, 300</th>
<th>350</th>
<th>400</th>
</tr>
</thead>
<tbody>
<tr>
<td>AS2</td>
<td>lbs.</td>
<td>70</td>
<td>76</td>
<td>79</td>
<td>87</td>
<td>92</td>
</tr>
<tr>
<td></td>
<td>(kg)</td>
<td>(32)</td>
<td>(34)</td>
<td>(36)</td>
<td>(39)</td>
<td>(42)</td>
</tr>
<tr>
<td>CJ1</td>
<td>lbs.</td>
<td>90</td>
<td>95</td>
<td>101</td>
<td>111</td>
<td>117</td>
</tr>
<tr>
<td></td>
<td>(kg)</td>
<td>(41)</td>
<td>(43)</td>
<td>(46)</td>
<td>(50)</td>
<td>(53)</td>
</tr>
<tr>
<td>CJ2</td>
<td>lbs.</td>
<td>112</td>
<td>118</td>
<td>124</td>
<td>133</td>
<td>139</td>
</tr>
<tr>
<td></td>
<td>(kg)</td>
<td>(51)</td>
<td>(54)</td>
<td>(56)</td>
<td>(60)</td>
<td>(63)</td>
</tr>
</tbody>
</table>

---

**NOTES:**

1. Reznor designed optional outside air hood or evaporative cooling module is required to ensure complete weather resistance. See Outside Air Hood Option for dimensions.
2. Burner and control access shown left side (facing air stream). Specify right side (Option AJ2) for opposite side access and connections.

---

**CLEARANCE FROM COMBUSTIBLES**

1. Furnace bottom - 0". (When installed on a roof curb on a combustible surface, the roof area enclosed within the curb must be either ventilated, left open, or covered with non-combustible material which has an "R" value of at least 5.0)
2. Unit top to overhangs - 36" (914mm)
3. Side opposite controls - 6" (152mm)
4. Control side - unit width plus 6" (152mm)
IGNITION CONTROL OPTIONS

STANDARD EQUIPMENT
INTERMITTENT SPARK PILOT: Automatic lighting of pilot with an electronic spark on a call for heat. Pilot gas flow is shut off between heat cycles. Certified by the Canadian Standards Association for use in Canada with natural gas only. Certified for use in the U.S.A. on outdoor units with natural gas or propane.

OPTION AH3 INTERMITTENT SPARK PILOT WITH TIMED LOCKOUT: Automatic lighting of pilot with an electronic spark on a call for heat. Pilot gas flow is shut off between heat cycles. This system also incorporates a lockout device which stops gas flow to the pilot if the pilot fails to light in 120 seconds. Reset of lockout requires manual interruption of the thermostat cycle. Approved for use with natural or propane gas.

GAS CONTROLS

SPACE HEATING APPLICATIONS
Option AG1 ONE-STAGE CONTROL: Single-stage gas valve which cycles on at 100% fire on a call for heat by a remote single-stage thermostat. Thermostat is not included.

Option AG2 TWO-STAGE CONTROL: Two-stage gas valve which fires at 100% or 50%, as required, on call by a remote two-stage thermostat. Thermostat is not included.

Option AG7 ELECTRONIC MODULATION (60°-85°F): Solid state control system, providing close temperature control via manifold pressure. On a call for heat from a remote electronic thermostat, controls modulate between 50% and 100%. Remote thermostat is included.

Option AG3 TWO-STAGE CONTROL FROM DUCTSTAT (60°-110°F): Two-stage gas valve which fires at 100% or 50% as required, on call from a unit-mounted, two-stage ductstat.

Option AG15 ELECTRONIC TWO-STAGE CONTROL USING DUCTSTAT (50°-130°F) WITH REMOTE TEMPERATURE SELECTION: Control is the same as Option AG8 except that the duct sensor setpoint may be reset from a remote selector. A room override thermostat (Option CL9) is available for use with this system. (See illustration)

MAKEUP AIR HEATING APPLICATIONS

A = Ductstat Temperature Module P/N 115848
B = Stage Adder Module, P/N 115849
(quantity varies - see Option description)

TEMPERATURE ADJUSTMENT: Same type of control as Option AG3, but the setpoint of the ductstat is adjustable from a remote temperature-selector. Includes factory-installed sensor and field-installed temperature-selector module with an adjustable stage-adder module.

Option AG8 ELECTRONIC MODULATION (55°-90°F) WITH DUCTSTAT: Solid state control system, providing close temperature control through regulated manifold pressure. On a call for heat from a unit-mounted ductstat, controls modulate between 50% and 100%, as required. A room override thermostat (Option CL9) is available for use with this system. Temperature range 55° - 90°F.

Option AG9 ELECTRONIC MODULATION (55°-90°F) WITH DUCTSTAT AND REMOTE TEMPERATURE SELECTION: Control is the same as Option AG8 except that the duct sensor setpoint may be reset from a remote selector. A room override thermostat (Option CL9) is available for use with this system. (See illustration)

AG21 ELECTRONIC MODULATION WITH DDC CONTROL: Used with customer-supplied 4-20MA or 0-10v input signal. Includes Maxitrol A200/SC10C-B6S1 signal conditioner and special modulating gas regulator.

Maxitrol Signal Selector (AG9 Only)

Duct Sensor

Unit-Mounted Ductstat P/N 41700 (quantity varies - see Option description)
Option AG39 ELECTRONIC MODULATION (SEE FIRING RATE TURNDOWN PERCENT IN TABLE BELOW): (Available with natural gas only)

Description
- Reznor Option AG39 is an electronic modulation gas control that will provide precise control of discharge air temperature over an increased range of outside air conditions. It is now available on selected Models of Reznor gas furnaces.
- This option allows the furnace input ratio to be fully modulated between 100% and 28 to 20%.
- The part-load thermal efficiency of this system complies with and exceeds the current seventy-five percent minimum requirement of ASHRAE standard 90.1 for part-load efficiencies. This system offers an average thermal efficiency over the range of modulation that is equal to or exceeds the full input rate thermal efficiency.
- Furnaces with Option AG39 require stainless steel burners, a stainless steel heat exchanger, and a stainless steel bottom pan. The gas train includes a single-stage gas valve, a modulating valve, and two gas pressure switches. The burner rack is equipped with one flash carry-over and a regulated gas lighter tube system. The carry-over lighter tube receives its gas supply through the regulator, simultaneously with the gas to the burner. Control of the system is through a Maxitrol #A1092 amplifier with a corresponding remote temperature dial (Maxitrol® #TD92-0509).

Sensor Location
- The duct temperature sensor will be located in the discharge ductwork (Refer to the installation manual for recommend location).

Sample Specification
- The unit shall have electronic modulation offering at least full modulation to 28% of full fire (capacity) input rate.
- Modulating gas control shall be certified by CSA for use in The United States and Canada.
- The furnace shall maintain an average thermal efficiency over the range of modulation that is equal to or exceeds the full input rate thermal efficiency.
- The furnace shall ignite at any fire rate within its modulation range, not just high fire on start.

Option AG40 ELECTRONIC MODULATION (SEE FIRING RATE TURNDOWN PERCENT IN TABLE BELOW) WITH DDC CONTROL: Same system as AG39 but includes signal conditioner for use with customer-supplied 4-20MA or 0-10V input signal. (Available with natural gas only)

<table>
<thead>
<tr>
<th>Options AG39 and 40</th>
<th>Maximum Trundown Percent</th>
<th>Input Range</th>
<th>Gas Supply Pressure Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model Size</td>
<td>MBH</td>
<td>kW</td>
<td>5” w.c.</td>
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<tr>
<td>RPB 125</td>
<td>20%</td>
<td>25 - 125</td>
<td>7.3 - 36.6</td>
</tr>
<tr>
<td>RPB 150</td>
<td>27%</td>
<td>40.3 - 150</td>
<td>11.8 - 44</td>
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<tr>
<td>RPB 175</td>
<td>23%</td>
<td>40.3 - 175</td>
<td>11.8 - 51.3</td>
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<td>RPB 200</td>
<td>26%</td>
<td>51.8 - 200</td>
<td>15.2 - 58.6</td>
</tr>
<tr>
<td>RPB 225</td>
<td>23%</td>
<td>51.8 - 225</td>
<td>15.2 - 65.9</td>
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<tr>
<td>RPB 250</td>
<td>28%</td>
<td>69 - 250</td>
<td>20.2 - 73.3</td>
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<td>RPB 300</td>
<td>23%</td>
<td>69 - 300</td>
<td>20.2 - 87.9</td>
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<tr>
<td>RPB 400</td>
<td>26%</td>
<td>100 - 400</td>
<td>29.3 - 117.2</td>
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</table>

*APPLICATION NOTE: If the installation of a packaged unit with more than one furnace section requires that any of the controls in this table be used in conjunction with an override thermostat, additional factory-installed relays are required. Since this application is not covered by “normal” control sequence, the additional relays (Option BG2) must be specified."
### Control Options (cont'd)

**Air Control Systems**

**Applies to Model RPB**

#### Inlet Air Control Options

<table>
<thead>
<tr>
<th>Option</th>
<th>Horiz. Inlet Air Opening</th>
<th>30% O/A Opening</th>
<th>with 100% O/A Dampers and Flanges and Insulation</th>
<th>Bottom Inlet Air Opening</th>
<th>30% O/A Opening</th>
<th>with 100% O/A Dampers and Flanges and Insulation</th>
<th>2 Pos. Dampers</th>
<th>Modulating Dampers</th>
<th>Mixed Air</th>
<th>Potentiometer</th>
<th>Warm-up</th>
<th>Controls</th>
<th>Optional O/A Changeover</th>
<th>Remote Pressure Null Switch</th>
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</tr>
</tbody>
</table>

*Outdoor units only.

**Standard Control - Outside Horizontal Air Inlet**

Option AR4 - Bottom Return Air Inlet, 100% Return Air Inlet only - Designed for 100% recirculated heating system. **OUTDOOR UNITS ONLY.**

Option AR6 - 30% Outside Horizontal Air Inlet, Bottom Return Air Inlet, 30% Outside Air Hood, Outside Air Dampers: 100% Return Air Inlet, 30% Outside Air Inlet with Hood (see Outside Air Hood section) and Manual Outside Air Damper - Supplies constant 30% or less outside air to recirculating heating system. Outside air hood is shipped separately for field installation. **OUTDOOR UNITS ONLY.**

Option AR7 - 30% Outside Horizontal Air Inlet, Bottom Return Air Inlet, 30% Outside Air Hood, Outside Air Dampers, Damper Motor: 100% Return Air Inlet, 30% Outside Air Inlet with Hood (see Outside Air Hood section) and Motorized Outside Air Damper - Supplies 30% outside air to a recirculating heating system at specific times, as controlled by a time clock or switch. On shutdown, the outside air damper closes. Outside air hood is shipped separately for field installation.

Option AR8 - Outside Horizontal Air Inlet, Outside Air Dampers, Damper Motor (2-Position): 100% Outside Air Inlet, with Two-Position (open/closed) Motorized Damper - 100% outside air system which provides Makeup air intermittently, usually in unison with a building exhauster. Outside air damper opens when unit is on; closes when units is off.
CONTROL OPTIONS (cont’d)
Applies to Model RPB

Option AR15 - Outside Horizontal Air Inlet, Bottom Return Air Inlet, Outside Air Dampers, Damper Motor (Modulating), Return Air Dampers, Mixed Air Controller, Potentiometer, Warm Up Control: 100% Outside Air and 100% Return Air Inlets with Dampers, Modulating Damper Motor, Potentiometer, Mixed Air Controller and Warm-up Control (ASHRAE Cycle II) - 100% return air on warm-up and automatically controlled mix of outside/return air to meet the temperature setting of the mixed air controller after warm-up. A minimum amount of outside air is allowed after warm-up as determined by the potentiometer setting. When used with mechanical cooling, optional air change over control may be added. An outside air change over control (not included in Option AR15 package) closes outside air dampers when the entering air reaches a set temperature (Usually 75 degrees F).

Option AR17 - Outside Horizontal Air Inlet, Bottom Return Air Inlet, Outside Air Dampers, Damper Motor (2-Position), Return Air Dampers: 100% Outside Air and 100% Return Air Inlets with Dampers and a Two-Position Damper Motor - 100% return air or 100% outside air as controlled by a switch or time clock. ON shutdown, the outside air damper closes.

Option AR18 - Outside Horizontal Air Inlet, Bottom Return Air Inlet, Outside Air Dampers, Damper Motor (Modulating), Return Air Dampers, Remote Potentiometer: 100% Outside Air and 100% Return Air Inlets with Dampers, a Modulating Damper Motor and Potentiometer - Mixture of return and outside air as controlled by a manually set remote potentiometer. ON shutdown, the outside air damper closes.

Option AR25 - Outside Horizontal Air Inlet, Bottom Return Air Inlet, Outside Air Dampers, Damper Motor with DDC, Return Air Dampers: Includes outside air damper and return air damper linked together with a modulating damper motor with an interface module to accept a 0 - 10 volt, or 4 - 20 mA signal from a D.D.C. system, to position the dampers for mixed air.

DISCHARGE AIR OPTIONS

<table>
<thead>
<tr>
<th>Horiz. Discharge Air Opening w/ Duct Flanges</th>
<th>Downturn Plenum for Vertical Discharge Air</th>
<th>Vertical Discharge Air Opening w/ Duct Flanges</th>
<th>2-Position Dampers</th>
</tr>
</thead>
<tbody>
<tr>
<td>STD</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>AQ5</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>AQ8</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

Standard Discharge - Installation that requires connection to horizontal ductwork before turning downward or where immediate downturn ductwork with horizontal connection is field supplied.
- 3/4" Duct Flange designed for "U" channel top/bottom ductwork connection and "L" type on each side

Option AQ5 - Installation where vertical ductwork is attached and sealed directly to the duct flange on the bottom of the downturn plenum cabinet.
- Downturn Plenum Cabinet
- 1" Duct Flange for slip-type connection (flange is perpendicular to the cabinet)

Options AQ8 - Installation where vertical ductwork is attached and sealed directly to the duct flange on the bottom of the downturn plenum cabinet. The two-position (open/close) dampers in the discharge opening are designed to isolate the unit from the building atmosphere when the system is not operating. The damper motor is located inside the downturn plenum cabinet.
- Downturn Plenum Cabinet
- Two-Position Dampers
- Direct-Coupled Motor (rated for use in discharge airstream)
- 1" Duct Flange for slip-type connection (flange is perpendicular to the cabinet)
OUTSIDE AIR HOOD OPTION
SCREENED OUTSIDE AIR HOOD FOR
100% OUTSIDE AIR INLET OPENING
Applies to Model RPB

DESCRIPTION
Option AS2, Outside Air Hood, is a weatherized screened hood designed to be field assembled and installed around the horizontal inlet air opening of a Model RPB or RPBL packaged unit or a Model RBL blower cabinet. The air hood includes a pre-assembled louver assembly designed to help eliminate moisture from the inlet air.

<table>
<thead>
<tr>
<th>Models</th>
<th>Width of Outside Air Hood</th>
</tr>
</thead>
<tbody>
<tr>
<td>RPB</td>
<td>in.</td>
</tr>
<tr>
<td>125</td>
<td>28 5/8</td>
</tr>
<tr>
<td>150, 175</td>
<td>34 1/8</td>
</tr>
<tr>
<td>200, 225</td>
<td>39 5/8</td>
</tr>
<tr>
<td>250, 300</td>
<td>47 7/8</td>
</tr>
<tr>
<td>350</td>
<td>53 3/8</td>
</tr>
<tr>
<td>400</td>
<td>58 7/8</td>
</tr>
</tbody>
</table>

Note: The width of the outside air hood is the same as the width of the blower cabinet.

30% OUTSIDE AIR HOOD SUPPLIED WITH INLET AIR OPTIONS AR6 AND AR7
(see description in Air Control Option section)

DESCRIPTION
The outside air hood included in the air inlet options that provide 30% outside air (Options AR6 and AR7) is shipped separately for field installation. The hood is factory assembled but requires field attachment to the blower cabinet. Illustrated instructions are provided.

<table>
<thead>
<tr>
<th>RPB</th>
<th>Width of 30% Hood</th>
</tr>
</thead>
<tbody>
<tr>
<td>in.</td>
<td>(mm)</td>
</tr>
<tr>
<td>125</td>
<td>28 5/8</td>
</tr>
<tr>
<td>150, 175</td>
<td>34 1/8</td>
</tr>
<tr>
<td>200, 225</td>
<td>39 5/8</td>
</tr>
<tr>
<td>250, 300</td>
<td>47 7/8</td>
</tr>
<tr>
<td>350</td>
<td>53 3/8</td>
</tr>
<tr>
<td>400</td>
<td>58 7/8</td>
</tr>
</tbody>
</table>
Reznor optional roof curbs are available in sizes to fit all Reznor packaged heating/makeup air systems. Roof curbs are shipped in pre-assembled sections constructed of 16 gauge aluminized steel, 2x6 wood nailers and 3# fiberglass insulation. Field assembly and installation are required.
**DESCRIPTION**

The 40RS Weathermakers® are chilled water fan-coil units that incorporate superior performance and versatility with space saving advantages and an attractive appearance. Their flexible design permits various configurations of in-space application. Nominal cooling capacities of 48,000 to 408,000 Btuh can be obtained. Heating capacities of 118,000 to 768,000 Btuh can be obtained by adding accessory hot water or nonfreeze steam coils.

**FEATURES**

- **Modular Construction** provides removable panels for interchangeable fan section positions.
- **Removable Panels** provide easy access for servicing.
- **Weather Armor Cabinet** is made of heavy-gage Galvaneal steel, bonded and coated with enamel.
- **OT Fan** has compact housing, moves more air at lower speeds than conventional fans.
- **Horizontal or Vertical Air Discharge.**
- **Cooling Coils** are constructed of copper tube with mechanically bonded, smooth plate aluminum fins. Supply and return connections are made from only one side of the unit, facilitating installation and service. These coils may also be used as efficient hot water heating coils.
- **Insulated Casing** eliminates condensation and also lowers the sound level.

**ACCESSORIES**

- **Air Discharge Plenum** with two-way deflection grilles for free-blow applications (40RS005 thru 024).
- **Return Air Grille** to cover the return air inlet when a finished appearance is desired (40RS005 thru 024).
- **Overhead Suspension Packages** contain unit hanger brackets for units 40RS008 thru 014. The package for units 40RS016 thru 034 contains a bottom panel to give the unit a finished appearance. Unit 40RS005 size does not require a suspension package.
- **Subbase** required on floor-mounted installations to provide access to the condensate connection (40RS016 and 024). Not required on the 40RS028 and 034.
- **Base Stand** to elevate a floor-mounted vertical unit for free-blow applications (40RS008 thru 014).
- **Horizontal Discharge Package** required on the vertical arrangement with horizontal discharge (40RS016 and 024).
- **Heating Coils** which mount downstream of the cooling coil. Either 2-row U-bend hot water coils or 1-row nonfreeze steam coils (40RS008 thru 034).
- **Drive Packages** for units not supplied with a factory-installed motor and drive (40RS016 thru 034).
- **Fan Motor Contactor** for 3-phase motors. Available with either 115-volt or 230-volt holding coil.
- **Filter Frame** for 40RS005 which will accept 1- or 2-in. filters. Larger units have filter tracks within the base unit.
PHYSICAL DATA

<table>
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<th>UNIT 40RS</th>
<th>005</th>
<th>008</th>
<th>010</th>
<th>012</th>
<th>014</th>
<th>016</th>
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<td>2 16x25x1</td>
<td>6 16x20x1</td>
<td>3 16x25x1</td>
<td>8 20x20x2</td>
<td>6 20x25x2</td>
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<td></td>
<td></td>
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<tr>
<td>CONN. (in.)</td>
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<tr>
<td>Cooling Coils</td>
<td>Supply</td>
<td>1 FPT</td>
<td>1 ¼ MPT</td>
<td>1 ½ MPT</td>
<td>1 ½ MPT</td>
<td>2 MPT</td>
<td>2 MPT</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Return</td>
<td>1 FPT</td>
<td>1 ¼ MPT</td>
<td>1 ½ MPT</td>
<td>1 ½ MPT</td>
<td>2 MPT</td>
<td>2 MPT</td>
<td></td>
<td></td>
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<tr>
<td>Hot Water Coils</td>
<td>Supply</td>
<td>-</td>
<td>1 ¼ MPT</td>
<td>1 ½ MPT</td>
<td>1 ½ MPT</td>
<td>1 ½ MPT</td>
<td>1 ½ MPT</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Return</td>
<td>-</td>
<td>1 ¼ MPT</td>
<td>1 ½ MPT</td>
<td>1 ½ MPT</td>
<td>1 ½ MPT</td>
<td>1 ½ MPT</td>
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<td></td>
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<tr>
<td>Steam Coils</td>
<td>Supply</td>
<td>-</td>
<td>1 ¼ MPT</td>
<td>1 ½ MPT</td>
<td>1 ½ MPT</td>
<td>1 ½ MPT</td>
<td>1 ½ MPT</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Return</td>
<td>-</td>
<td>1 ¼ MPT</td>
<td>1 ½ MPT</td>
<td>1 ½ MPT</td>
<td>1 ½ MPT</td>
<td>1 ½ MPT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensate</td>
<td>¾ FPT</td>
<td>¾ FPT</td>
<td>¾ FPT</td>
<td>¾ FPT</td>
<td>¾ FPT</td>
<td>1 MPT</td>
<td>1 MPT</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Two separate coils assembled as one unit; face split into an upper and a lower section.
†Refer to Fan Motors and Drives table and Drive Selection Data
‡Maximum operating limits are 200 psig and 400 F

DIMENSIONS

Certified dimension drawings are available on request.

*With accessory filter frame, 2-4. †Includes accessory subbase.
**PHYSICAL DATA (cont)**

**FAN MOTORS AND DRIVES (1750 rpm)**

<table>
<thead>
<tr>
<th>UNIT</th>
<th>MOTOR</th>
<th>MOTOR PULLEY</th>
<th>FAN PULLEY</th>
<th>BELTS</th>
<th>FSR</th>
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<tbody>
<tr>
<td>40RS</td>
<td>Hp</td>
<td>NEMA, Frame Size</td>
<td>PDR (in.)</td>
<td>Bore (in.)</td>
<td>PPD (in.)</td>
</tr>
<tr>
<td>005</td>
<td>½</td>
<td>48</td>
<td>1.9-2.9</td>
<td>½</td>
<td>10.0</td>
</tr>
<tr>
<td>008, 010*</td>
<td>1</td>
<td>56</td>
<td>3.4-4.4</td>
<td>½</td>
<td>7.0</td>
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<tr>
<td>008, 010</td>
<td>1</td>
<td>143T</td>
<td>3.4-4.4</td>
<td>½</td>
<td>7.0</td>
</tr>
<tr>
<td>012, 014</td>
<td>2</td>
<td>145T</td>
<td>3.4-4.4</td>
<td>½</td>
<td>7.0</td>
</tr>
<tr>
<td>016</td>
<td>3</td>
<td>182T</td>
<td>4.3-5.3</td>
<td>1¾</td>
<td>11.0</td>
</tr>
<tr>
<td>024</td>
<td>3</td>
<td>184T</td>
<td>4.3-5.3</td>
<td>1¾</td>
<td>11.0</td>
</tr>
<tr>
<td>028, 034</td>
<td>3</td>
<td>184T</td>
<td>4.3-5.3</td>
<td>1¾</td>
<td>11.0</td>
</tr>
</tbody>
</table>

*Accessory drive packages: Others are standard equipment

PPD - Pulley Pitch Diameter

*Single phase. All other are 3 phase

---

**DRIVE SELECTION DATA**

<table>
<thead>
<tr>
<th>UNIT</th>
<th>MOTOR</th>
<th>BETWEEN SHAFT CTRS (in.)</th>
<th>FAN SHAFT DIAM (in.)</th>
</tr>
</thead>
<tbody>
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<td>Hp</td>
<td>NEMA, Frame Size</td>
<td>Shaft Diam (in.)</td>
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<td>56</td>
<td>½</td>
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<tr>
<td>008, 010</td>
<td>2</td>
<td>143T</td>
<td>½</td>
</tr>
<tr>
<td>012, 014</td>
<td>2</td>
<td>56T</td>
<td>½</td>
</tr>
<tr>
<td>012, 014</td>
<td>2</td>
<td>145T</td>
<td>½</td>
</tr>
<tr>
<td>016</td>
<td>3</td>
<td>182T</td>
<td>1¼</td>
</tr>
<tr>
<td>016</td>
<td>5</td>
<td>184T</td>
<td>1¼</td>
</tr>
<tr>
<td>024</td>
<td>3</td>
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<td>1¼</td>
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<td>5</td>
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<td>1¾</td>
</tr>
<tr>
<td>028, 034</td>
<td>5</td>
<td>182T</td>
<td>1¼</td>
</tr>
<tr>
<td>028, 034</td>
<td>5</td>
<td>184T</td>
<td>1¼</td>
</tr>
<tr>
<td>028, 034</td>
<td>7½</td>
<td>213T</td>
<td>1¾</td>
</tr>
</tbody>
</table>

*Factory available 2 hp - 56 frame; Carrier part no HD68DL206 for 208-3-60, and HD68DL851 for 230/460-3-60

*Factory available 3 hp - 56 frame; Carrier part no HD68DL206 for 208-3-60, and HD68DL851 for 230/460-3-60

*Factory available 3 hp - 184 frame; Carrier part no HD58DG200 for 208-3-60, and HD58DG202 for 230/460-3-60

---

**STANDARD DISCHARGE ARRANGEMENTS**

---

**LOCATION OF HEATING COIL CONNECTIONS**

<table>
<thead>
<tr>
<th>COIL TYPE</th>
<th>ARR 008-014</th>
<th>ARR 016, 024</th>
<th>ARR 028, 034</th>
<th>ARR 044, 055</th>
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</thead>
<tbody>
<tr>
<td>1-Row</td>
<td>Horiz L or R</td>
<td>L or R</td>
<td>L or R</td>
<td>R</td>
</tr>
<tr>
<td>Steam</td>
<td>Vert Sup - L or R</td>
<td>R</td>
<td>L or R</td>
<td>R</td>
</tr>
<tr>
<td>2-Row</td>
<td>Horiz L or R</td>
<td>L or R</td>
<td>R</td>
<td>L or R</td>
</tr>
<tr>
<td>Hot</td>
<td>Vert Ret - R</td>
<td>L or R</td>
<td>R</td>
<td>L or R</td>
</tr>
<tr>
<td>Water</td>
<td>Vert</td>
<td>L or R</td>
<td>R</td>
<td>L or R</td>
</tr>
</tbody>
</table>

L = Left  R = Right  Sup = Supply  Ret = Return

*When facing return air inlet side

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**NOTES**

1. Dashed lines indicate accessories available from factory.
2. Cross-hatched lines indicate parts not supplied by factory.
3. Dashed arrows indicate alternate air flow paths.
SELECTION PROCEDURE (With Example)

The cooling coil ratings for the 40RS units are presented in the form of "O" curves. To find the "O" value required, the load, entering water temperature and effective coil surface temperature (apparatus dewpoint - ADP) must be known. A conversion chart is used to find the ADP from known entering and leaving air conditions. Heating can be accomplished with the 40RS units, either by supplying hot water to the chilled water coil or with an auxiliary hot water or steam heating coil.

I Determine job requirements. (Cooling coil used for heating.)

Given:

- Dehumidified air quantity: 4815 cfm
- Entering water temperature: 85.5 F
- Entering air temperature, dry bulb ($t_{ad}$): 85.5 F
- Entering air temperature, wet bulb ($t_{aw}$): 65.5 F
- Leaving air temperature, dry bulb ($t_{ld}$): 57.5 F
- Leaving air temperature, wet bulb ($t_{lw}$): 55.0 F
- Grand total heat (GTH): 155,000 Btuh
- Heating load at 64 F EAT: 340,000 Btuh
- External static pressure: 25 in wg

Find:
- GPM required for cooling
- Pressure drop

Minimum entering hot water temperature (assuming that cooling coil will be used for heating with the gpm required for cooling) 85 and rpm

II Select unit size and ADP.

A 40RS012 or 014 provides the required cfm at a coil face velocity of 450 fpm (Unit Air Capacity table). The ADP is found on the Conversion Chart as follows:

1. Draw a line connecting the entering and leaving wet-bulb temperatures
2. Draw a horizontal line from the coil face velocity until it intersects the first line drawn
3. Read the ADP at the intersection of the two lines
4. Draw a third line from the entering dry-bulb thru the ADP and read the resulting leaving dry-bulb temperature.

40RS012 40RS014
ADP = 51.9 ADP = 53.3
LDB = 58.8 F LDB = 57.3 F

Since the required leaving dry-bulb temperature is 57.5 F, the 40RS014 must be selected.

III Find gpm and pressure drop.

\[ Q = \frac{GTH (1000's)}{ADP - t_{aw}} \]

\[ Q = \frac{155}{53.3 - 45.0} = 18.7 \]

Entering the proper "O" curve, read a gpm of 35.5. A pressure drop of 23.0 ft is read from the Pressure Drop Curve.

IV Find hot water temperature.

From the Heating Performance Curve for the cooling coil, read an HTI (heat transfer index) value at 35.5 gpm and 450 fpm.

\[ HTI = 3.8 \]

\[ HTI = \frac{heating load (1000's)}{t_{ew} - t_{ea}} \]

\[ 3.8 = \frac{340}{t_{ew} - 64} \]

\[ t_{ew} = 64 + \frac{340}{3.8} = 153.5 \text{ F} \]

Leaving air temperatures over 140 F (135 F for 40RS005) must be avoided to protect the motor and bearings.

\[ t_{la} = \frac{heating load (Btuh)}{108 \times \text{cfm}} + t_{ea} \]

\[ t_{la} = \frac{340,000}{108 \times 4815} + 64 = 129.4 \text{ F} \]

IV Determine fan performance.

Determine total static pressure requirements (internal plus external)

Find the internal static pressure loss from the Pressure Loss of Unit Components table.
- Cooling coil (wet) = 0.38
- Filters = 0.07
- Return air grille = 0.06
- 0.51 in wg

Add the external static pressure loss of the ductwork
- Internal = 51
- External = 25
- Total SP = 76

From the Fan Performance table, read 1.95 bhp and 898 rpm.

TO SELECT ACCESSORY HOT WATER COIL

I Given:

- Air quantity: 4815 cfm
- $t_{ea}$: 64 F
- Heating load: 272,000 Btu
- Entering water temperature: 200 F

II Find:

Gpm and pressure drop

III Determine HTI.

\[ HTI = \frac{heating load (1000's)}{t_{ew} - t_{ea}} \]

\[ HTI = \frac{272}{200 - 64} = 2.72 \times 136 = 2.0 \]

IV Read gpm and pressure drop.

Enter Heating Coil Ratings with the HTI and cooling coil face velocity

Gpm = 25; Pressure drop = 3 ft

EXAMPLE (Accessory Steam Coil)

I Given:

- Air quantity: 4815 cfm
- $t_{ea}$: 64 F
- Heating load: 272,000 Btu
- Steam Pressure: 80 psig

II Check coil performance.

Coil capacity at 60 F entering air and 2 psig = 166,000 Btu (from Accessory Steam Heating Coil Capacity table)

- Correction factor for 64 F entering air and 80 psig = 1.64 (from Steam Btu Constants table)
- Actual coil performance = 166,000 x 1.64 = 272,000 Btuh
PERFORMANCE DATA

COOLING COIL CAPACITY

Pressure Drop

GPM THRU COIL

Cooling

Q (THOUSANDS) * \( t_{adp} - t_{ew} \) (F)

Heat Transfer Index *

GPM THRU COIL

Heating

\[ HTI = \frac{\text{heat load (1000 Btu/h)}}{t_{ew} - t_{edph}} \]
PERFORMANCE DATA (cont)

COOLING COIL CAPACITY

![Graph showing pressure drop vs. GPM thru coil](image)

![Graph showing cooling capacity vs. flow rate](image)

![Graph showing heat transfer index vs. GPM thru coil](image)

Heat Transfer Index (HTI) = \( \frac{\text{heat load (1000 Btu/h)}}{t_{\text{ew}} - t_{\text{eddb}}} \)
PERFORMANCE DATA (cont)

COOLING COIL CAPACITY

Pressure Drop

Cooling

Q (THOUSANDS) = GRAND TOTAL HEAT (BTU/HR)
\[ \frac{t_{dp} - t_{ew}}{F} \]

Heating

\[ HTI = \frac{\text{heat load (1000 Btu/h)}}{t_{ew} - t_{edb}} \]
COOLING COIL CAPACITY

Pressure Drop vs. GPM Thru Coil

Cooling

Q (Thousands) vs. Grand Total Heat (BTU/HR)
\[ T_{oad} - T_{ew}(F) \]

Heat Transfer Index

Heating

\[ HTI = \frac{heat\,load\,(1000\,Btuh)}{t_{ew} - t_{edb}} \]
PERFORMANCE DATA (cont)

COOLING COIL CAPACITY

\[ Q \text{ (THOUSANDS)} = \frac{\text{GRAND TOTAL HEAT (BTU/HR)}}{T_{adp} - T_{ew} [F]} \]

*HTI* = \( \frac{\text{heat load (1000 Btu)}}{T_{ew} - T_{edt}} \)
PERFORMANCE DATA (cont)

COOLING COIL CAPACITY

Pressure Drop

TOTAL GPM THRU COILS

Q (THOUSANDS)* \frac{GRAND TOTAL HEAT (BTU/HR)}{t_{odp} - t_{ew} (F)}

Cooling

Heat Transfer Index *

TOTAL GPM THRU COILS

*HTI = \frac{heat load (1000 Btu/h)}{t_{ew} - t_{eddb}}
PERFORMANCE DATA (cont)

COOLING COIL CAPACITY

**Pressure Drop**

![Graph showing pressure drop vs. total GPM through coils.](image)

![Graph showing cooling load vs. total GPM through coils.](image)

\[ Q \text{ (thousands)} = \text{GRAND TOTAL HEAT (BTU/HR)} \]

\[ = t_{adp} - t_{ew} (F) \]

![Graph showing heat transfer index vs. total GPM through coils.](image)

\[ HTI = \frac{\text{heat load (1000 Btuh)}}{t_{ew} - t_{edt}} \]
*HTI = \frac{\text{heat load (1000 Btu/hr)}}{t_{ew} - t_{ad}}
**COOLING COIL CAPACITY**

**PERFORMANCE DATA (cont)**

**Pressure Drop**

![Graph of pressure drop vs. total GPM thru coils.]

**Cooling**

![Graph of total GPM thru coils vs. Q (thousands) and grand total heat (BTU/hr).]

**Heating**

![Graph of heat transfer index vs. total GPM thru coils.]

\[ *HTI = \frac{\text{heat load (1000 Btuh)}}{t_{ew} - t_{eddb}} \]
PERFORMANCE DATA (cont)

ACCESSORY HOT WATER HEATING COIL CAPACITY

\[ *HTI = \frac{\text{heat load (1000 Btuh)}}{I_{ew} - I_{edb}} \]

Air velocities shown on all charts above are based on cooling coil face areas.
PERFORMANCE DATA (cont)

40RS016, 024

ACCESSORY HOT WATER HEATING COIL CAPACITY

**Pressure Drop**

**Heat Transfer Index**

Air velocities shown on all charts above are based on cooling coil face areas.
ACCESSORY HOT WATER HEATING COIL CAPACITY

\[ \text{Pressure Drop} \]

**HEAT TRANSFER INDEX**

\[ \text{HTI} = \frac{\text{heat load (1000 Btu/h)}}{t_{ew} - t_{edb}} \]

Air velocities shown on all charts above are based on cooling coil face areas.
### PERFORMANCE DATA (cont)

**ACCESSORY STEAM HEATING COIL CAPACITY (Btuh)**

<table>
<thead>
<tr>
<th>UNIT</th>
<th>ROWS</th>
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<th>350</th>
<th>400</th>
<th>450</th>
<th>500</th>
<th>550</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Lvg Air Temp (F)</td>
<td>Lvg Air Capacity (1000 Btuh)</td>
<td>Lvg Air Temp (F)</td>
<td>Lvg Air Capacity (1000 Btuh)</td>
<td>Lvg Air Temp (F)</td>
<td>Lvg Air Capacity (1000 Btuh)</td>
</tr>
<tr>
<td>40RS</td>
<td>-208</td>
<td>99</td>
<td>100</td>
<td>97</td>
<td>110</td>
<td>95</td>
<td>120</td>
</tr>
<tr>
<td>016</td>
<td>092</td>
<td>122</td>
<td>126</td>
<td>140</td>
<td>111</td>
<td>124</td>
<td>116</td>
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<td>024</td>
<td>092</td>
<td>133</td>
<td>137</td>
<td>146</td>
<td>129</td>
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<td>151</td>
<td>156</td>
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<td>151</td>
<td>164</td>
<td>156</td>
<td>170</td>
<td>176</td>
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</table>

**COOLING COIL FACE VELOCITY (FPM)**

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<th>ROWS</th>
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<th>400</th>
<th>500</th>
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<tr>
<td></td>
<td></td>
<td>Lvg Air Temp (F)</td>
<td>Lvg Air Capacity (1000 Btuh)</td>
<td>Lvg Air Temp (F)</td>
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<tr>
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<td>-208</td>
<td>122</td>
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<tr>
<td>034</td>
<td>092</td>
<td>150</td>
<td>151</td>
<td>164</td>
</tr>
</tbody>
</table>

**NOTES:**
1. Coil face velocity based on cooling coil face area. Actual cooling coil face area is smaller. See Physical Data.
2. Ratings are based on 2 psig steam pressure at inlet to coil. This pressure does not include pressure drop across the valve.
3. Air capacity is cfm of standard air (70°F and 29.92 in Hg, barometric pressure) passing thru heating coils.
4. To obtain pounds of condensate per hour, divide capacity in Btuh by 970. Although this factor decreases as pressure increases, its use gives sufficiently accurate results for normal applications.
5. Maximum working conditions for steam heating coils are 200 psig or 400°F. Leaving air temperatures over 140°F must be avoided to protect the motor and bearings.

---

**STEAM BTU CONSTANTS (Based on 2 psig Steam and 60°F DB Entering Air)**

<table>
<thead>
<tr>
<th>ENT AIR TEMP (F)</th>
<th>0</th>
<th>2</th>
<th>5</th>
<th>10</th>
<th>15</th>
<th>20</th>
<th>30</th>
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<th>50</th>
<th>60</th>
<th>80</th>
<th>100</th>
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<tr>
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<td>1.53</td>
<td>1.57</td>
<td>1.62</td>
<td>1.70</td>
<td>1.77</td>
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<td>2.07</td>
<td>2.13</td>
<td>2.23</td>
<td>2.32</td>
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<td>1.51</td>
<td>1.56</td>
<td>1.64</td>
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<td>1.86</td>
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<td>1.44</td>
<td>1.50</td>
<td>1.57</td>
<td>1.64</td>
<td>1.70</td>
<td>1.79</td>
<td>1.87</td>
<td>1.94</td>
<td>2.00</td>
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<td>1.81</td>
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<td>1.27</td>
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<td>1.37</td>
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<td>1.75</td>
<td>1.81</td>
<td>1.88</td>
<td>1.98</td>
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<td>1.31</td>
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<td>1.45</td>
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<td>1.60</td>
<td>1.68</td>
<td>1.75</td>
<td>1.81</td>
<td>1.92</td>
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<td>1.24</td>
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<td>1.54</td>
<td>1.62</td>
<td>1.69</td>
<td>1.75</td>
<td>1.85</td>
<td>1.94</td>
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**Formulas:**
1. Actual steam coil capacity = Btu constant \times\text{ coil capacity in Btuh at 2 psig steam and 60°F DB entering air}
2. Leaving air temperature = entering air temp + \frac{\text{Btuh}}{\text{cfm} \times 1.08}
## PERFORMANCE DATA (cont)

### PRESSURE LOSS OF UNIT COMPONENTS (in. wg)

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**NOTES:**
1. Filter resistance for 40RS024, 028 and 034 units is based on high velocity (permanent-type) filters. Resistance for other units is based on low velocity (throwaway-type) filters.
2. For 40RS005 only, dry cooling coil and plenum resistances are incorporated in the Fan Performance table. The additional resistance for a wet cooling coil is shown.
3. Dashes indicate that the component is not available or cannot be used.
4. No correction is needed for this arrangement.
**PERFORMANCE DATA (cont)**

**FAN PERFORMANCE**

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**Total Static Pressure (in. wg)**

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**NOTES**

1. Ratings for unit 40RS005 include dry cooling coil and plenum resistances. Accessory and wet cooling coil resistances must be added if required.
2. Ratings for units 40RS008 thru 034 do not include any coil or accessory resistances.
## PERFORMANCE DATA (cont)

### PLENUM AIR DISTRIBUTION

#### Front Discharge Only

<table>
<thead>
<tr>
<th>UNIT 40RS</th>
<th>AIR QTY (cfm)</th>
<th>VERTICAL VANE SETTING (degrees)</th>
<th>LENGTH OF BLOW (ft)</th>
<th>MINIMUM CEILING HT (ft)</th>
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<td>005</td>
<td>1600</td>
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<td>45</td>
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#### Front Discharge with Two Side-Discharge Grilles

<table>
<thead>
<tr>
<th>UNIT 40RS</th>
<th>VERTICAL VANE SETTING (degrees)</th>
<th>FRONT Length of Blow (ft)</th>
<th>Minimum Ceiling Ht (ft)</th>
<th>EACH SIDE Length of Blow (ft)</th>
<th>Minimum Ceiling Ht (ft)</th>
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</table>

**NOTES**

1. Length of Blow is the distance from the unit where the velocity of the airstream has been reduced to less than 75 fpm. There will be some diffusion of the cooled air beyond this point. For the cfm range of the units, Length of Blow is approximately proportional to cfm.

2. If the length of the room is less than the blow of the unit, the airstream will impinge on the opposite wall and may cause drafts.

3. Minimum Ceiling Height is the height required to distribute the cooled air without causing objectionable air motion in the occupied zone. This height is measured from floor to beams, lighting fixtures, or other obstructions.

4. The values listed in the table for “Front Discharge With Two Side Discharge Grilles” are based on full side discharge areas and:
   a. Center of front discharge area of the 40RS016 blocked off by turning 10 vertical vanes until they are parallel to the front discharge
   b. Full front discharge area of the 40RS024

5. Plenum with front outlet only not recommended for use at high cfm due to high outlet velocity and long blow. Additional field-supplied side outlet grilles should be used.

## ELECTRICAL DATA (60-Hz)

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<tr>
<th>UNIT 40RS</th>
<th>VOLTS</th>
<th>SYSTEM VOLTAGE</th>
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<th>FULL LOAD AMPS</th>
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* Motors are designed for satisfactory operation at 10% above and 10% below system voltages. Voltage fluctuations should not exceed the allowable limits indicated.

NOTE: Fan motors are not supplied with 40RS016 thru 034 units.
GUIDE SPECIFICATIONS

**Furnish and Install** _chilled water fan-coil unit(s) in the location(s) shown on the plans_

**Total Cooling Capacity** shall be ... Btu/h or more and total room sensible capacity shall be ... Btu/h or more when supplied with ... gpm of chilled water entering at ... °F leaving at ... °F under the following conditions:

Air entering unit: ... °F db, ... °F wb
Air leaving unit: ... °F db, ... °F wb

The maximum pressure drop thru the coil shall not exceed ... ft of water.

**Cooling Coils** shall be of nonferrous construction with mechanically bonded smooth plate fins with a total face area of not less than ... sq ft. All tube joints shall be brazed with phosphor copper or silver alloy. (When more than one coil is used, provisions should exist for increased latent vent removal at partial loads.)

**Fan Section** shall have forward-curved blades, double-inlet fans (single-inlet on 40RS005) mounted on a common shaft. Fans shall be statically and dynamically balanced and shall run on permanently lubricated bearings. Fans shall deliver ... cfm with ... in wg external (or total) static pressure operating at ... rpm, ... hp.

**Casing** shall be made of Galvanneal steel, bonderized and finished with baked enamel.

**Unit Construction** shall be such that horizontal or vertical discharge may be achieved by relocating the fan section. Provisions shall exist for suspending the unit from an overhead support.

**Dimension** — Unit cabinet shall be ... in. wide, ... in. deep and ... in. high.

**Filters** (factory supplied on 40RS008 thru 014) shall be standard size and not less than ... in. thick. They shall have a face area of ... sq ft or more. High velocity permanent (low velocity throwaway) filters shall be used and shall be protected from the cooling coil condensate.

**Accessories** — A hot water (nonfreeze steam) heating coil shall be enclosed in the unit and shall have a capacity of ... Btu/h with an air quantity of ... cfm entering at ... °F. Water quantity shall be ... gpm entering at ... °F. (Steam pressure shall be ... psig.)

In addition, the following accessories shall be supplied: Air discharge plenum, return air grille, overhead suspension package, base or subbase package, fan motor contactor, horizontal discharge package, and drive packages (Filter frame on 40RS005 only.)