SPECIFICATIONS GROUP

Facility Services Subgroup

DIVISION 23 - HEATING, VENTILATING, AND AIR CONDITIONING (HVAC)

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SECTION 230500
COMMON WORK RESULTS FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. Certain requirements common to all the mechanical and electrical trades (Fire Suppression, Plumbing, HVAC, Electrical, and Tele/Data) are specified in Division 20. To avoid repetition, they are not repeated in each relevant Section. These requirements are applicable to the work of this Division, and are hereby incorporated by reference.

1.2 SUMMARY

A. This Section includes the following:

1. Piping materials and installation instructions common to most piping systems.
2. Transition fittings.
3. Dielectric fittings.
4. Mechanical sleeve seals.
5. Sleeves.
6. Escutcheons.
7. Grout.
8. HVAC demolition.
9. Equipment installation requirements common to equipment sections.
10. Painting and finishing.
11. Concrete bases.
12. Supports and anchorages.
13. Containment Room Sealing Requirements.
14. Rated fire penetration sealants.
15. Material and workmanship.
16. Access panels.

1.3 REFERENCES

A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form part of this specification to the extent referenced. Publications are referenced in the text by the basic designations only.

1. American Iron and Steel Institute (ASI)
2. National Fire Protection Association (NFPA)
   a. NFPA 70 National Electric Code

3. American Society for Testing and Materials (ASTM)

   a. ASTM A36Standard Specification for Carbon Structural Steel

   b. ASTM A53 Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

   c. ASTM A109Standard Specification for Steel, Strip, Carbon (0.25 Maximum Percent), Cold-Rolled

   d. ASTM A123Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

   e. ASTM A240Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications

   f. ASTM A500Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes

   g. ASTM A501Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing

   h. ASTM A633 Standard Specification for Normalized High-Strength LowAlloy Structural Steel Plates

   i. ASTM A635Standard Specification for Steel, Sheet and Strip, HeavyThickness Coils, Carbon, Commercial Steel, Drawing Steel, Structural, High-Strength Low-Alloy, and High-Strength Low-Alloy with Improved Formability, Hot-Rolled

   j. ASTM A653Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process

   k. ASTM A682Standard Specification for Steel, Strip, High-Carbon, ColdRolled

   l. ASTM A924Standard Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process

   m. ASTM A1011Standard Specification for Steel, Sheet and Strip, HotRolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability

   n. ASTM A1018Standard Specification for Steel, Sheet and Strip, Heavy Thickness Coils, Hot Rolled, Carbon, Structural, High-Strength LowAlloy, Columbium or Vanadium, and High-Strength Low-Alloy with Improved Formability

   o. ASTM B117Standard Practice for Operating Salt Spray (Fog) Apparatus

   p. ASTM B633Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel

   q. ASTM C920Standard Specification for Elastomeric Joint Sealants

   r. ASTM C1193Standard Guide for Use of Joint Sealants

s. ASTM D522Standard Test Methods for Mandrel Bend Test of Attached Organic Coatings

t. ASTM D523Standard Test Method for Specular Gloss

u. ASTM D610 Standard Test Method for Evaluating Degree of Rusting on Painted Steel Surfaces.

v. ASTM D2247Standard Practice for Testing Water Resistance of Coatings in 100 per Relative Humidity

w. ASTM D3451Standard Guide for Testing Coating Powders and Powder Coatings

x. ASTM E84 Standard Test Method for Surface Burning Characteristics of Building Materials

y. ASTM F1136Standard Specification for Chromium/Zinc Corrosion Protective Coatings for Fasteners

4. American Wood-Preservers' Association (AWPA)

a. AWPA C2 Lumber, Timber, Bridge Ties and Mine Ties - Preservative Treatment by Pressure Processes

b. AWPA C9 Plywood - Preservative Treatment by Pressure Process

c. AWPA C20 Structural Lumber - Fire-Retardant Treatment by Pressure Processes

d. AWPA C22 Lumber and Plywood for Permanent Wood FoundationsPreservative Treatment by Pressure Processes

e. AWPA C27Plywood-Fire-Retardant Treatment by Pressure Processes

5. American Welding Society (AWS)

6. Code of Federal Regulations (CFR)

7. Metal Framing Manufactures Association (MFMA)

a. MFMAMetal Framing Standards Publication

8. Underwriters Laboratories (UL)

a. UL 723 Test for Surface Burning Characteristics of Building Materials

1.4 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.

B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and chases.

E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters. F. The following are industry abbreviations for plastic materials:

1. CPVC: Chlorinated polyvinyl chloride plastic.
2. PE: Polyethylene plastic.
3. PVC: Polyvinyl chloride plastic.

G. The following are industry abbreviations for rubber materials:

1. EPDM: Ethylene-propylene-diene terpolymer rubber.
2. NBR: Acrylonitrile-butadiene rubber.

1.5 SUBMITTALS

A. Product Data: For the following:

1. Transition fittings.
2. Dielectric fittings.
3. Mechanical sleeve seals.
4. Escutcheons.
5. Containment room sealants.
6. Rated fire penetration sealants. B. Welding certificates.

1.6 QUALITY ASSURANCE

A. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."

B. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

C. Align components. No strain shall be placed on weld during welding. No part of pipe shall be offset more than 20 percent of thickness. Set flanges and branches properly.

D. Weld only by approved acetylene or electric welding processes. All welders shall hold certificate from approved insurance company.

E. Conduct test to demonstrate suitability of procedures to be used in making welds that conform to specified requirements. F. Welder Qualification:

1. Test welders to demonstrate ability to make acceptable welds. Tests conducted for qualification of welder for work under one Division or Section shall not qualify welder for work under another Division or Section.
2. Tests shall be as prescribed for welder qualification in Section IX of the ASME code.
3. Records of tests shall be as follows: Each welder shall be assigned an identifying number, letter or symbol. Identifying mark shall be stamped adjacent to welds made by this welder. Identification shall be at top of horizontal piping and at front of vertical piping.
4. Maintain record of welders employed, showing dates and results of tests and identifying mark assigned to each welder. Certify records and make them accessible to Owner's project representative and/or project manager. Before completion of project, one copy of records
5. No qualification shall be older than three years when welder commences work on this project. If welder has not welded in required welding process for a period of six months, he shall be re-certified.

G. Welding Tests

1. As designated by Architect, remove welds for destructive testing or for testing by non-destructive means. Tests shall be as determined by Architect.
2. If, in Architect's opinion, welds so tested do not meet requirements of Sections VIII and IX of ASME, then the contractor shall pay for the costs of the tests. Remove welds welded by that welder, at no cost to the Owner. Rewelding shall be performed by qualified welder other than welder whose welds did not pass test. Welders whose welds were defective shall not be employed on site for remainder of project.
3. Welding of stanchions, brackets, anchors and other welding not performed on pipe joints shall be in accordance with requirements of AWS specifications and requirements.

H. Electrical Characteristics for HVAC Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

B. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

C. Protect and cover equipment (VAV boxes, coils, fans, pumps, control valves, etc) and ductwork components with plastic when stored on site to prevent entrance of dirt, debris and moisture.

1.8 COORDINATION

A. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for HVAC installations.

B. Coordinate installation of required supporting devices and set sleeves in poured-inplace concrete and other structural components as they are constructed.

C. Coordinate requirements for access panels and doors for HVAC items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Division 08.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the manufacturers specified.

2. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.

2.2 PIPE, TUBE, AND FITTINGS

A. Refer to individual Division 23 for pipe, tube, and fitting materials and joining methods.

B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.3 TRANSITION FITTINGS

A. Plastic-to-Metal Transition Fittings: CPVC and PVC one-piece fitting with manufacturer's Schedule 80 equivalent dimensions; one end with threaded brass insert, and one solvent-cement-joint end.

1. Available Manufacturers:

a. Eslon Thermoplastics.

B. Plastic-to-Metal Transition Adaptors: One-piece fitting with manufacturer's SDR 11 equivalent dimensions; one end with threaded brass insert, and one solventcement-joint end.

1. Available Manufacturers:

a. Thompson Plastics, Inc.

C. Plastic-to-Metal Transition Unions: MSS SP-107, CPVC and PVC four-part union. Include brass end, solvent-cement-joint end, rubber O-ring, and union nut.

1. Available Manufacturers:

a. NIBCO INC.

b. NIBCO, Inc.; Chemtrol Div.

2.4 DIELECTRIC FITTINGS

A. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.

B. Insulating Material: Suitable for system fluid, pressure, and temperature.

C. Dielectric Unions: Factory-fabricated, union assembly, for 250-psig minimum working pressure at 180 deg F.

1. Manufacturers:
   a. Capitol Manufacturing Co.
   b. Central Plastics Company.
   c. Eclipse, Inc.
   d. Epco Sales, Inc.
   e. Hart Industries, International, Inc.
   f. Watts Industries, Inc.; Water Products Div.
   g. Zurn Industries, Inc.; Wilkins Div.

D. Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 150- or 300-psig minimum working pressure as required to suit system pressures.

1. Manufacturers:
   a. Capitol Manufacturing Co.
   b. Central Plastics Company.
   c. Epco Sales, Inc.
   d. Watts Industries, Inc.; Water Products Div.

E. Dielectric-Flange Kits: Companion-flange assembly for field assembly. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.

1. Manufacturers:
   a. Advance Products & Systems, Inc.
   b. Calpico, Inc.
   c. Central Plastics Company.
   d. Pipeline Seal and Insulator, Inc.
   e. Thunderline

2. Separate companion flanges and steel bolts and nuts shall have 150- or 300psig minimum working pressure where required to suit system pressures.

F. Dielectric Couplings: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225 deg F.

1. Available Manufacturers:
   a. Calpico, Inc.
   b. Lochinvar Corp.

G. Dielectric Nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig minimum working pressure at 225 deg F.

1. Manufacturers:
   a. Perfection Corp.
   b. Precision Plumbing Products, Inc.
   c. Sioux Chief Manufacturing Co., Inc.
   d. Victaulic Co. of America.

2.5 MECHANICAL SLEEVE SEALS

A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.

1. Available Manufacturers:
   a. Advance Products & Systems, Inc.
   b. Calpico, Inc.
   c. Metraflex Co.
   d. Pipeline Seal and Insulator, Inc.
   e. Thunderline
2. Sealing Elements: EPDM interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
3. Pressure Plates: Plastic. Include two for each sealing element.
4. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating or Stainless steel of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.6 SLEEVES

A. Galvanized-Steel Sheet: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

B. Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 40, galvanized, plain ends.

C. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.

1. Underdeck Clamp: Clamping ring with set screws.

2.7 ESCUTCHEONS

A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.

B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished chrome-plated finish.

C. One-Piece, Cast-Brass Type: With set screw.

1. Finish: Polished chrome-plated

D. Split-Casting, Cast-Brass Type: With concealed hinge and set screw.

1. Finish: Polished chrome-plated

E. One-Piece, Stamped-Steel Type: With set screw and chrome-plated finish.

F. Split-Plate, Stamped-Steel Type: With concealed hinge, set screw, and chromeplated finish.

G. One-Piece, Floor-Plate Type: Cast-iron floor plate.

H. Split-Casting, Floor-Plate Type: Cast brass with concealed hinge and set screw.

2.8 GROUT

A. Description: ASTM C 1107, Grade B, non-shrink and nonmetallic, dry hydrauliccement grout.

1. Characteristics: Post-hardening, volume-adjusting, non-staining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
2. Design Mix: 5000-psi, 28-day compressive strength.
3. Packaging: Premixed and factory packaged.

2.9 CONTAINMENT ROOM SEALANTS

A. Description: Field applied joint sealant conforming to ASTM C920 “Specifications for Elastomeric Joint Sealants”.

1. Manufacturers:
   a. Dow Chemical, 732-RTV silicone rubber
   b. GE

B. Sealant shall be mildew resistant and shall be specifically design for exposure to a high degree of moisture. Sealant shall be compatible with and adhere to substrate and materials that are in direct contact with the sealant. Sealant shall maintain seal under normal expected movements of substrates. C. Color shall be clear or white.

2.10 RATED FIRE PENETRATION SEALANTS

A. Submit 3M, Hilti or Firespec sealants for approval prior to use.

B. Sealants, caulking and devices shall be rated the same as the wall rating they are used in.

2.11 ACCESS PANELS

A. Description: Interior construction access panels.

1. Manufacturers:
    a. Milcor
    b. Knapp
    c. Nystorm
    d. Inland Steel

B. Coordinate selection with other Divisions supplying similar access panels.

C. Access panels shall have same fire rating classification as surface penetrated.

PART 3 - EXECUTION

3.1 HVAC DEMOLITION

A. Refer to Division 01 and Division 02 for general demolition requirements and procedures.

B. Refer to drawings for general description of areas requiring demolition.

C. Refer to General Contractor's/Construction Manager's Instructions for existing equipment and materials that shall remain the property of the Owner.

D. Where it is noted that items of value are not to be returned to the Owner, the items shall become the property of the Contractor. Storage or sale of items on the project site is prohibited. Items shall be removed from site and legally disposed of.

E. Protection: Ensure the safe passage of persons in and around the building/site during demolition. Prevent injury to persons and damage to property. Provide adequate shoring and bracing to prevent collapse. Immediately repair damage to the condition before being damaged to the satisfaction of the architect and Owner. Take effective measures to prevent windblown dust.

F. Utilities: Maintain utilities except those requiring removal or relocation. Keep utilities in service and protect from damage. Do not interrupt utilities serving in-use areas without first obtaining permission from the utility company and the Owner. Provide temporary services as required.

G. Disconnect, demolish, and remove HVAC systems, equipment, and components indicated to be removed.

1. Piping to Be Removed: Remove portion of piping indicated to be removed and cap remaining piping with same or compatible piping material.
2. Piping to Be Abandoned in Place: Drain piping and cap piping with same or compatible piping material.
3. Ducts to Be Removed: Remove portion of ducts indicated to be removed and cap remaining ducts with same or compatible ductwork material.
4. Ducts to Be Abandoned in Place: Cap ducts with same or compatible ductwork material.

5. Equipment to Be Removed: Disconnect and cap services and remove equipment.
6. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
7. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.

H. If pipe, insulation, or equipment to remain is damaged in appearance or is unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality.

3.2 PIPING SYSTEMS - COMMON REQUIREMENTS

A. Install piping according to the following requirements and Division 23 Sections specifying piping systems.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping to permit valve servicing.

G. Install piping at indicated slopes as specified in other Division 23 sections.

H. Install piping free of sags and bends.

I. Install fittings for changes in direction and branch connections.

J. Install piping to allow application of insulation.

K. Select system components with pressure rating equal to or greater than system operating pressure.

L. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:

1. New Piping:
   a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deeppattern type.
   b. Chrome-Plated Piping: One-piece, cast-brass type with polished chrome-plated finish.

c. Insulated Piping: One-piece, stamped-steel type.

d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Onepiece, cast-brass type with polished chrome-plated finish.

e. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece or split-casting, cast-brass type with polished chrome-plated finish.

f. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass type

g. Bare Piping in Equipment Rooms: One-piece, cast-brass type.

h. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece, floor-plate type.

2. Existing Piping: Use the following:

a. Chrome-Plated Piping: Split-casting, cast-brass type with chromeplated finish.

b. Insulated Piping: Split-plate, stamped-steel type hinge

c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Splitcasting, cast-brass type with chrome-plated finish.

d. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-casting, cast-brass type with chrome-plated finish.

e. Bare Piping in Unfinished Service Spaces: Split-casting, cast-brass type.

f. Bare Piping in Equipment Rooms: Split-casting, cast-brass type.

g. Bare Piping at Floor Penetrations in Equipment Rooms: Split-casting, floor-plate type.

3.3 PENETRATIONS AND SLEEVES

A. General

1. Lay out penetration and sleeve openings in advance, to permit provision in work. Coordinate work carefully with architectural and structural work. Set sleeves and conduit in forms before concrete is poured. Provide remedial work where sleeves and conduits are omitted or improperly placed. Remedial work includes core drilling (see requirements below) for penetrations if walls are poured, or otherwise constructed, without required sleeves. Provide core drilling (see requirements below) of existing construction. Do not penetrate structural members without Structural Engineer’s/Architect's written approval.

2. Provide sleeves and packing materials at penetrations of foundations, walls, basement floors, slabs (except on-grade), partitions and floors. Sleeve installation shall meet NFPA-101 requirements, UL rated assemblies requirements, and materials requirements of these specifications. Submit a list of the UL listed details that the Contractor intends on using on this project in all rated assemblies.

3. Sleeves that penetrate outside walls, basement slabs, footings and beams shall be waterproof. Sleeves that penetrate floors shall be fireproof and waterproof.

4. Sleeves for insulated pipe and duct in non-fire rated construction shall accommodate continuous insulation without compression. Sleeves and/or penetrations in fire rated construction that do not require fire dampers shall be packed with fire rated material that shall maintain the fire rating of the

   wall. Seal ends of penetrations to provide continuous vapor barrier where insulation is interrupted. Where fire dampers are required, install sleeve and damper assembly in accordance with damper listing.

5. Where pipes passing through openings are exposed in finished rooms, finishes of filling materials shall match and be flush with adjoining floor, ceiling, and wall finishes.

6. Identify unused sleeves and slots for future installation. Fill slots, sleeves and other openings in floors or walls if not used. Fill spaces in openings after installation of pipe, duct, conduit or cable. Fill for floor penetrations shall prevent passage of water, smoke, fire, and fumes. Fill shall be fire resistant in fire floors and walls, and shall prevent passage of air, smoke and fumes.

7. Do not support piping risers or conduit on sleeves.

8. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 7 for materials.

9. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements. Verify final equipment locations for roughing-in.

10. Installation Testing, Listings and Approvals

    a. Installation of sleeves, fill and packing shall meet material manufacturer's recommendations exactly, particularly as regards safety, ventilation, removal of foreign materials and other details of installation. Dam openings as recommended. Remove flammable materials used for damming and forming seals in fire-rated construction.

    b. Sleeve penetration methods shall be water- and gas-tight and shall meet requirements of ASTM E-119 Standard Methods of Fire Tests of Building Construction and Materials.

    c. Fire-stop penetration seal methods and materials shall be FM-approved and UL-listed as applicable. They shall have the same rating as the structure penetrated. Submit manufacturer's detail sheet indicating assembly rating.

       1) Inspect foamed sealants to ensure manufacturer's optimum cell structure and color ranges.

B. Install sleeves for pipes passing through concrete and masonry walls, gypsumboard partitions, and concrete floor and roof slabs. Sleeves are not required for slab-on-grade floors unless specified otherwise. Sleeves are required for coredrilled holes on any floor.

   1. Cut sleeves to length for mounting flush with both surfaces.

a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.

2. Install sleeves in new walls and slabs as new walls and slabs are constructed.

3. Install sleeves that are large enough to provide 1/4 inch annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:

   a. Steel Pipe Sleeves: For pipes smaller than NPS 6.

   b. Steel Sheet Sleeves: For pipes NPS 6 and larger, penetrating gypsumboard partitions.

   c. Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level. Refer to Division 07 for flashing.

      1) Seal space outside of sleeve fittings with grout.

4. Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Division 07 for materials and installation.

C. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1 inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

1. Install steel pipe for sleeves smaller than 6 inches in diameter.

2. Install cast-iron "wall pipes" for sleeves 6 inches and larger in diameter.

3. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

D. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for 1 inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

1. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

E. Duct Sleeves and Prepared Openings

1. Provide galvanized-steel sheet duct sleeves for round ducts 15 inches and smaller. Provide prepared, framed openings for round ducts larger than 15 inches and for square, rectangular and flat oval ducts, except as specified otherwise. Sleeves shall meet SMACNA requirements.

2. Provide galvanized-steel sheet duct sleeves for ducts through 1-, 2- or 3-hour fire-rated construction and smoke partitions, regardless of size and shape of ducts. Sleeves shall maintain fire rating of construction penetrated. Sleeve and seal materials, construction and clearances shall meet requirements of SMACNA Fire Damper and Heat Stop Guide for Air Handling Systems.
3. Prepared openings shall be framed to provide 1 inch clearance between framing and duct or duct insulation.
4. Provide 4 inches wide 20 gauge galvanized sheet metal collars at sleeves and prepared openings, sized to cover entire duct penetration including sleeve and seal, and to accommodate duct and insulation as necessary. Edges shall have milled lips ground smooth. Paint to match finish of duct or as directed by Architect.
5. All duct penetrations through concrete floors in mechanical rooms shall be provided with 2 inches high water stopped curbs surrounding the openings. This applies to mechanical rooms located above the lowest floor level.

F. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 07 for materials.

G. Verify final equipment locations for roughing-in.

H. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

3.4 CORE DRILLING

A. Core drilling shall be avoided in new construction. Set sleeves prior to installation of structure for passage of pipes, conduit and ducts. Where core drilling is unavoidable (e.g. when individual sleeves are not installed or incorrectly located) or required by renovation projects, locate required openings prior to coring and submit locations for review.

B. Coordinate openings with other Divisions.

C. Do not disturb existing systems. Protect areas from damage.

D. Thoroughly investigate existing conditions in vicinity of required opening prior to coring.

3.5 PIPING JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 23 Sections specifying piping systems.

B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.

F. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.

2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

G. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.

H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

I. Plastic Piping Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:

1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.

2. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.

3. PVC Pressure Piping: Join schedule number ASTM D 1785, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other-than-schedule-number PVC pipe and socket fittings according to ASTM D 2855.

4. PVC Non-pressure Piping: Join according to ASTM D 2855.

J. Plastic Pressure Piping Gasketed Joints: Join according to ASTM D 3139.

K. Plastic Non-pressure Piping Gasketed Joints: Join according to ASTM D 3212.

L. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D 2657.

1. Plain-End Pipe and Fittings: Use butt fusion.

2. Plain-End Pipe and Socket Fittings: Use socket fusion.

M. Fiberglass Bonded Joints: Prepare pipe ends and fittings, apply adhesive, and join according to pipe manufacturer's written instructions.

3.6 PIPING CONNECTIONS

A. Make connections according to the following, unless otherwise indicated:

1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.

2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.

3. Dry Piping Systems: Install dielectric unions and flanges to connect piping materials of dissimilar metals.

4. Wet Piping Systems: Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals.

3.7 EXPANSION PROVISIONS

A. Installation of piping must allow for expansion using offsets, loops, swing joints, expansion joints, etc. as necessary to prevent undue strain. Takeoffs from mains to runouts shall not have less than three-elbow swing.

B. Mains and risers with loops or offsets shall be securely anchored to structure so as to impart expansion towards loops or offsets. Anchors shall be constructed of heavy forged wrought iron, secured to pipe and to structure. Provide vibration isolation as required.

C. Provide pipe alignment guides as required to guide expanding pipe to move freely from anchor points toward expansion joints, offsets, etc.

3.8 ANCHORS AND INSERTS

A. Inserts shall be iron or steel of type to receive machine bolt head or nut after installation. Inserts shall permit adjustment of bolt in one horizontal direction and shall develop strength of bolt when installed in properly cured concrete. B. Provide anchors for attachment of equipment supports and hangers.

3.9 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.

B. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.

C. Install equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations. D. Install equipment to allow right of way for piping installed at required slope.

E. Avoid interference with structure and with work of other trades, preserving adequate headroom and clearing doors and passageways, to satisfaction of Architect and in accordance with code requirements.

F. Distribute equipment loads on building structural members provided for equipment support. Roof-mounted equipment shall be installed and supported on structural steel.

G. Provide suspended platforms, strap hangers, brackets, shelves, stands or legs for floor, wall or ceiling mounting of equipment.

H. Provide steel supports and hardware for proper installation of hangers, anchors and guides.

I. Provide cuts, weights, and other pertinent data required for proper coordination of equipment support provisions and installation.

J. Structural steel and hardware shall conform to Standard Specifications of ASTM; use of steel and hardware shall conform to requirements of Section Five of Code of Practice of American Institute of Steel Construction.

K. Verify site conditions and dimensions of equipment to ensure access for proper installation of equipment without disassembly that will void warrantee. Report in writing to Architect, prior to purchase or shipment of equipment involved, on conditions that may prevent proper installation.

L. For all equipment installed external to the building; whether on roofs, supports, grade, etc., the installation shall comply with wind loading and impact requirements of the applicable codes for this project site. All equipment provided for this project shall be certified by the manufacturer that the equipment meets the applicable seismic, wind, earthquake, and hurricane impact requirements as set forth by the Authority Having Jurisdiction.

3.10 PAINTING

A. Painting of HVAC systems, equipment, and components is specified in Division 09.

B. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

C. Equipment installed shall have shop coat of non-lead gray paint. Hangers and supports shall have one coat of non-lead red primer. Machinery (e.g. pumps, fans and air handling units) shall be stenciled with equipment name. Stencil shall be at least 6 inches high for large equipment, 2 inches high for small equipment.

D. Note requirement for Architect's approval invoked under paragraph MATERIALS AND WORKMANSHIP regarding finish of material and equipment that is visible or subject to corrosive or atmospheric conditions.

3.11 CONCRETE BASES

A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.

1. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit.
2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18 inch centers around the full perimeter of the base.
3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to supported equipment.
6. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

7. Use 3000 psi, 28-day compressive-strength concrete and reinforcement as specified in Division 03.

3.12 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Refer to Division 05 for structural steel.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor HVAC materials and equipment. C. Field Welding: Comply with AWS D1.1.

3.13 ERECTION OF WOOD SUPPORTS AND ANCHORAGES

A. Cut, fit, and place wood grounds, nailers, blocking, and anchorages to support, and anchor HVAC materials and equipment.

B. Select fastener sizes that will not penetrate members if opposite side will be exposed to view or will receive finish materials. Tighten connections between members. Install fasteners without splitting wood members. C. Attach to substrates as required to support applied loads.

3.14 GROUTING

A. Mix and install grout for HVAC equipment base bearing surfaces, pump and other equipment base plates, and anchors.

B. Clean surfaces that will come into contact with grout.

C. Provide forms as required for placement of grout.

D. Avoid air entrapment during placement of grout.

E. Place grout, completely filling equipment bases.

F. Place grout on concrete bases and provide smooth bearing surface for equipment.

G. Place grout around anchors.

H. Cure placed grout.

3.15 CONTAINMENT ROOM SEALING REQUIREMENTS

A. General

1. Work that penetrates or is mounted on ceilings, walls, floors or other surfaces throughout containment rooms shall be sealed as outlined below in addition to sealing specified elsewhere in the Specifications. Sealing shall include, but not be limited to, the following:

   a. Diffusers, registers and grilles.

   b. Ductwork penetrations.

   c. Piping and tubing (including control tubing).

   d. Access doors.

   e. Conduits.

2. Completely seal the perimeter joints around insulated and uninsulated penetrations and surface-mounted items.

B. Installation

1. Preparation, priming, application, curing and protection of the sealant shall be in conformance with the recommendations of the sealant manufacturer.
2. If necessary, fill voids with backer rods as recommended by the sealant manufacturer.
3. Mask edges of exposed joints if required to make neat joints and prevent excessive misplacement of sealant onto exposed surfaces adjacent to joints.
4. Clean surfaces so that no foreign matter of loose particles or dust detrimental to adhesion are present.
5. Perform sealant work after adjacent painting work is complete and dry.
6. Sealant shall be free of voids, be applied in one continuous bead and be tooled concave and smooth.
7. Strip off protective masking tape after sealant has been applied; strip toward the joints.
8. Protect sealant from damage during and after curing period. If damage occurs, repair.
9. Clean off excess sealant or sealant smears adjacent to joints by methods and with cleaning materials approved by the manufacturers of the sealant.

3.16 ACCESS AND ACCESS PANELS

A. Access panels are generally not shown on the drawings, but shall be provided.

B. Provide proper access to materials and equipment that require inspection, replacement, repair or service, and coordinate their delivery with the installing Trade. If proper access cannot be provided, confer with Architect as to best method of approach for minimizing effect of reduced access that may result.

C. Coordinate and prepare a location, size, and function schedule of access panels required to fully service equipment and deliver to a representative of the installing Trade. Furnish and install distinctively colored buttons (color as selected by Architect) in finished ceiling to identify access panels

D. Furnish access panels for installation under other Sections where fire dampers, smoke dampers, volume dampers, smoke detectors, controls, shut-off valves, control valves, check valves, or other items installed under this Section require access and are concealed in floor, wall, furred space or above ceiling.

E. Ceilings consisting of lay-in or removable splined tiles do not require access panels and dampers, splitters, or test hole openings above ceiling shall have location marked with thumbtack on finished ceiling panel. Location shall be noted on record drawings.

F. Access panels shall be at least large enough to remove the component requiring access. Where individual components (e.g. control valves) requiring access are within 8 inches of the finished surface, panels shall be a minimum of 12 inch by 12 inch.

Where component is more than 8 inches from surface and at equipment requiring service (e.g. VAV boxes, fan boxes, fire dampers), access panels shall be a minimum of 24 inch x 24 inch.

3.17 MATERIALS AND WORKMANSHIP

A. Work shall be neat and rectilinear. Ductwork, piping and conduit shall run concealed except in mechanical rooms and areas where no hung ceiling exists.

Install material and equipment in accordance with manufacturers written instructions. Installation shall operate safely and without leakage, undue wear, noise, vibration, corrosion or water hammer. Work shall be properly and effectively protected, and pipe and duct openings shall be temporarily closed to prevent obstruction and damage before completion.

B. Except as specified otherwise, material and equipment shall be new. Provide supplies, appliances and connections necessary for complete and operational installation. Provide components required or recommended by OSHA and applicable NFPA documents.

C. Owner will not be responsible for material and equipment before testing, commissioning, and acceptance.

END OF SECTION

SECTION 230513
COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. Certain requirements common to all the mechanical and electrical trades (Fire Suppression, Plumbing, HVAC, Electrical, and Tele/Data) are specified in Division 20. To avoid repetition, they are not repeated in each relevant Section. These requirements are applicable to the work of this Division, and are hereby incorporated by reference.

1.2 SUMMARY

A. Section includes general requirements for single-phase and polyphase, generalpurpose, horizontal, small and medium, squirrel-cage induction motors for use on alternating-current power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

1.3 COORDINATION

A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:

1. Motor controllers.
2. Torque, speed, and horsepower requirements of the load.
3. Ratings and characteristics of supply circuit and required control sequence.
4. Ambient and environmental conditions of installation location.
5. Variable-speed drive controllers. **PART 2 - PRODUCTS**

2.1 GENERAL MOTOR REQUIREMENTS

A. Comply with requirements in this Section except when stricter requirements are specified in HVAC equipment schedules or Sections.

B. Comply with NEMA MG 1 unless otherwise indicated.

C. Comply with IEEE 841 for severe-duty motors.

D. Motors under 1/2 HP shall be designed for 120V, 60 Hz, single phase, unless otherwise specified.

E. Motors 1/2 HP and over shall be voltages as indicated in schedules on drawings.

F. Individual pumps serving variable flow systems and VAV fans with a motor horsepower of 5 hp or larger shall be provided with variable speed drives that will result in pump or fan motor demand of no more than 30 percent of design wattage at 50 percent of design flow.

2.2 MOTOR CHARACTERISTICS

A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet (1000 m) above sea level.

B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.3 POLYPHASE MOTORS

A. Description: NEMA MG 1, Design B, medium induction motor.

B. Efficiency: All motors shall be premium efficiency type as defined in NEMA MG 1 and shall have their efficiencies determined in accordance with IEEE Standard 112 Method B. The NEMA nominal efficiency shall be listed on the motor nameplate. C. Minimum nominal efficiencies shall be as follows:

Premium Efficiency Motor Totally Enclosed Fan-Cooled (TEFC)				Premium Efficiency Motor Open Drip-Proof (ODP)			
Size HP	Speed (rpm)			Size HP	Speed (rpm)		
	1200	1800	3600		1200	1800	3600
	NEMA Nominal Efficiency				NEMA Nominal Efficiency		
1	82.5	85.5	78.5	1	82.5	85.5	80.0
1.5	87.5	86.5	85.5	1.5	86.5	86.5	85.5
2	88.5	86.5	86.5	2	87.5	86.5	86.5
3	89.5	89.5	88.5	3	89.5	89.5	86.5
5	89.5	89.5	89.5	5	89.5	89.5	89.5
7.5	91.7	91.7	91.0	7.5	91.7	91.0	89.5
10	91.7	91.7	91.7	10	91.7	91.7	90.2
15	92.4	92.4	91.7	15	92.4	93.0	91.0
20	92.4	93.0	92.4	20	92.4	93.0	92.4
25	93.0	93.6	93.0	25	93.0	93.6	93.0
30	93.6	93.6	93.0	30	93.6	94.1	93.0
40	94.1	94.1	93.6	40	94.1	94.1	93.6
50	94.1	94.5	94.1	50	94.1	94.5	93.6
60	94.5	95.0	94.1	60	95.0	95.0	94.1
75	95.0	95.4	94.5	75	95.0	95.0	94.5

100	95.4	95.4	95.0	100	95.0	95.4	94.5
125	95.4	95.4	95.4	125	95.4	95.4	95.0
150	95.8	95.8	95.4	150	95.8	95.8	95.4
200+	95.8	96.2	95.8	200+	95.4	95.8	95.4

D. Multispeed Motors: Variable torque.

1. For motors with 2:1 speed ratio, consequent pole, single winding.
2. For motors with other than 2:1 speed ratio, separate winding for each speed.

E. Service Factor: 1.15.

F. Multispeed Motors: Separate winding for each speed.

G. Rotor: Random-wound, squirrel cage.

H. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.

I. Temperature Rise: One class below insulation rating. Example: Class B temperature rise for Class F insulation.

J. Insulation: Class F or Class H as noted below.

K. Code Letter Designation:

1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
2. Motors Smaller Than 15 HP: Manufacturer's standard starting characteristic.

L. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.4 ADDITIONAL REQUIREMENTS FOR POLYPHASE MOTORS

A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.

B. Motors Used with Variable-Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer. Motors shall be premium efficiency "inverter-duty" or "drive duty" motors, compatible with the drive to which it is connected. Use of the motor with a VFD shall not adversely affect the operation, useful life or warranty of the motor.

1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width-modulated inverters.
2. Premium-Efficient Motors: Class B temperature rise; Class F insulation.
3. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.
5. Motor windings shall be spike resistant to withstand 1,600 peak volts. Motors shall have shaft grounding system to protect bearings from induced voltage. Shaft grounding system shall have very low drag, less than 1/2 percent of motor HP, and shall operate for a minimum of three (3) years without periodic adjustments. All consumables of the shaft grounding system shall be replaceable without a shutdown of the motor or VFD. System shall be as manufactured by SGS (Albany, Oregon) or approved equal.
6. Motors used with VFD shall have a minimum three (3) year manufacturer warranty.

C. Severe-Duty Motors: Comply with IEEE 841, with 1.15 minimum service factor.

D. Premium Efficiency Motors (non-VFD): Class B temperature rise; Class F insulation.

2.5 SINGLE-PHASE MOTORS

A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:

1. Permanent-split capacitor.
2. Split phase.
3. Capacitor start, inductor run.
4. Capacitor start, capacitor run.

B. Multispeed Motors: Variable-torque, permanent-split-capacitor type.

C. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.

D. Motors 1/20 HP and Smaller: Shaded-pole type.

E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

F. Electronically Commutated Motors (ECM): Motors shall be an electronic commutation (EC) motor specifically designed for HVAC applications. AC induction type motors are not acceptable. Motors shall be permanently lubricated with heavy-duty ball bearings to match the load, and prewired to the specific voltage and phase. Internal motor circuitry shall convert AC power supplied to the equipment to DC power to operate the motor. Motor shall be speed controllable down to 20 percent of full speed (5:1 turndown). Speed shall be controlled by either a potentiometer dial mounted on the motor or by a 0-10 VDC control signal. Motor shall be a minimum of 85 percent efficient at all speeds.

2.6 STARTERS

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

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.

2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.

3. Rockwell Automation, Inc.; Allen-Bradley brand.

4. Siemens Energy & Automation, Inc.

5. Square D; a brand of Schneider Electric

6. Cutler-Hammer

7. Clark

8. Arrow Hart

B. Furnish starters for HVAC equipment, except units served by MCC provided under Division 26 or those served by variable frequency drives. Provide control and other related wiring including interlocks. Power wiring (to panelboards, disconnect switches, starters and motors) will be provided under Division 26. Starters that are not integral to equipment will be installed and wired under Division 26, Electrical, and furnished under this Section.

C. Starters that require interlocks or remote control shall be magnetic with HAND-OFF- AUTOMATIC switch (fast-slow-off-auto for two speed motors) in cover.

Provide magnetic starters with auxiliary contacts, buttons and switches. Refer to other Division 23 sections and control drawings for interlock requirements. Starters shall be by single manufacturer.

1. Each 3-phase, 60 Hz motor shall be provided with magnetic starter with hand-off-automatic switch.

2. Other motors shall be provided with a manual starter with ON-OFF switch.

3. Control relay for each starter shall be for operation on 120V, single phase. Provide transformer of sufficient capacity within starter case.

4. Provide inverse time limit overload and under voltage protection in each leg and with pilot lights.

5. Provide red and green On-Off pilot lights.

6. Provide nameplates with engraved white lettering to designate area and equipment served.

7. Starters for refrigeration machines shall be furnished by unit manufacturer.

8. Furnish for all single speed motors, 25 HP and above, 95 percent power factor correction capacitors. Capacitors shall be in NEMA enclosure of the same rating as the motor's starter.

2.7 DRIVES

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

1. Allis-Chalmers

2. Browning

3. Woods

B. Drives for belted motors shall be flame retardant V-belt drives with adjustable motor sheave. Drives shall be as short as practical and shall have number of belts necessary to transmit required horsepower without undue slip or strain. C. Sheaves shall be balanced statically and dynamically.

D. Hazardous exhaust drives and all drives for smoke control or pressurization fans shall be sized for 150 percent safety factor and shall be dual groove (2 belt) minimum.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION

SECTION 230516
EXPANSION FITTINGS AND LOOPS FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Flexible, ball-joint packed expansion joints.
2. Slip-joint, packed expansion joints.
3. Metal, compensator packless expansion joints.
4. Metal-bellows packless expansion joints.
5. Rubber packless expansion joints.
6. Grooved-joint expansion joints.
7. Alignment guides and anchors.
8. Pipe loops and swing connections.

1.3 PERFORMANCE REQUIREMENTS

A. Compatibility: Products shall be suitable for piping service fluids, materials, working pressures, and temperatures.

B. Capability: Products to absorb 200 percent of maximum axial movement between anchors.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Delegated-Design Submittal: For each anchor and alignment guide, including analysis data, signed and sealed by the qualified professional engineer responsible for their preparation.

1. Design Calculations: Calculate requirements for thermal expansion of piping systems and for selecting and designing expansion joints, loops, and swing connections.
2. Anchor Details: Detail fabrication of each anchor indicated. Show dimensions and methods of assembly and attachment to building structure.

3. Alignment Guide Details: Detail field assembly and attachment to building structure.
4. Schedule: Indicate type, manufacturer's number, size, material, pressure rating, end connections, and location for each expansion joint.

1.5 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Product Certificates: For each type of expansion joint, from manufacturer.

1.6 CLOSEOUT SUBMITTALS

A. Maintenance Data: For expansion joints to include in maintenance manuals.

1.7 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Pipe and Pressure-Vessel Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

PART 2 - PRODUCTS

2.1 PACKED EXPANSION JOINTS

A. Flexible, Ball-Joint Packed Expansion Joints:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Advanced Thermal Systems, Inc.
    b. Hyspan Precision Products, Inc.
2. Standards: ASME Boiler and Pressure Vessel Code: Section II, "Materials"; ASME B31.9, "Building Services Piping," for materials and design of pressurecontaining parts and bolting.
3. Material: Carbon-steel assembly with asbestos-free composition packing.
4. Design: Provide 360-degree rotation and angular deflection.
5. Minimum Pressure Rating: 250 psig at 400 deg F
6. Angular Deflection for NPS 6 and Smaller: 30 degree minimum.
7. Angular Deflection for NPS 8 and Larger: 15 degree minimum.
8. Seal Type: Two carbon steel and graphite seals suitable for continuous operation at temperature up to 650 deg F.
9. Internal Ball: Plated with minimum 1-mil chrome cover.

10. Ball Socket: One- or two-piece design with integral socket/retainer.
    a. Stuffing Box: Incorporates containment seals and compression seals for containment of injectable packing.
    b. Packing Cylinders: Provides packing under full line pressure with check valves to prevent blowback.

11. End Connections for NPS 2 and Smaller: Threaded.
12. End Connections for NPS 2-1/2 and Larger: Flanged.

B. Slip-Joint Packed Expansion Joints:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Adsco Manufacturing LLC.
    b. Advanced Thermal Systems, Inc.
    c. Hyspan Precision Products, Inc.
2. Standard: ASTM F 1007.
3. Material: Carbon steel with asbestos-free PTFE packing.
4. Design: With internal guide and injection ports for repacking under full system pressure. Housing shall be furnished with drain ports and lifting ring. Include drip connection if used for steam piping.
5. Configuration: Single joint with base and double joint with base class(es), unless otherwise indicated.
6. Slip Tube for sizes NPS 1-1/2 through NPS 16: Schedule 80.
7. Slip Tube for sizes NPS 18 through NPS 24: Schedule 60.
8. Sliding Surface: 2 mil thick chrome finish.
9. End Connections: Flanged or welded ends to match piping system.

2.2 PACKLESS EXPANSION JOINTS

A. Metal, Compensator Packless Expansion Joints:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Adsco Manufacturing LLC.
    b. Flexicraft Industries.
    c. Flex Pression Ltd.
    d. Flex-Weld, Inc.
    e. Hyspan Precision Products, Inc.
    f. Metraflex, Inc.
    g. Senior Flexonics Pathway.
    h. Unaflex.
    i. Unisource Manufacturing, Inc.
2. Minimum Pressure Rating: 200 psig, unless otherwise indicated.
3. Description: Totally enclosed, externally pressurized, multi-ply bellows isolated from fluid flow by an internal pipe sleeve and external housing.
4. Joint Axial Movement: 2 inches of compression and 1/2 inch of extension.
5. Configuration for Copper Tubing: Multi-ply, phosphor-bronze bellows with copper pipe ends.

a. End Connections for Copper Tubing NPS 2 and Smaller: Solder joint or threaded.
b. End Connections for Copper Tubing NPS 2-1/2 to NPS 4: Threaded.

6. Configuration for Steel Piping: Multi-ply, stainless-steel bellows; steel-pipe end connections; and carbon-steel shroud.

a. End Connections for Steel Pipe NPS 2 and Smaller: Threaded.
b. End Connections for Steel Pipe NPS 2-1/2 to NPS 4: Threaded or Welded.

B. Metal-Bellows Packless Expansion Joints:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Adsco Manufacturing LLC.
   b. American BOA, Inc.
   c. Badger Industries, Inc.
   d. Expansion Joint Systems, Inc.
   e. Flex-Hose Co., Inc.
   f. Flexicraft Industries.
   g. Flex Pression Ltd.
   h. Flex-Weld, Inc.
   i. Flo Fab inc.
   j. Hyspan Precision Products, Inc.
   k. Metraflex, Inc.
   l. Proco Products, Inc.
   m. Senior Flexonics Pathway.
   n. Tozen Corporation.
   o. Unaflex.
   p. Unisource Manufacturing, Inc.
   q. Universal Metal Hose; a subsidiary of Hyspan Precision Products, Inc.
   r. U.S. Bellows, Inc.
   s. WahlcoMetroflex.
2. Standards: ASTM F 1120 and EJMA's "Standards of the Expansion Joint Manufacturers Association, Inc."
3. Type: Circular, corrugated bellows with external tie rods.
4. Minimum Pressure Rating: 200 psig, unless otherwise indicated.
5. Configuration: Single joint with base and double joint with base class(es), unless otherwise indicated.
6. Expansion Joints for Copper Tubing: Single or multiply phosphor-bronze bellows, copper pipe ends, and brass shrouds.

   a. End Connections for Copper Tubing NPS 2 and Smaller: Solder joint or threaded.
   b. End Connections for Copper Tubing NPS 2-1/2 to NPS 4: Solder joint or threaded.
   c. End Connections for Copper Tubing NPS 5 and Larger: Flanged.

7. Expansion Joints for Steel Piping: Single- or multi- ply stainless-steel bellows, steel pipe ends, and carbon-steel shroud.

a. End Connections for Steel Pipe NPS 2 and Smaller: Threaded.
b. End Connections for Steel Pipe NPS 2-1/2 and Larger: Flanged or Welded.

C. Rubber Packless Expansion Joints:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Amber/Booth Company, Inc.; a div. of Vibration Isolation Products of Texas, Inc.
   b. Flex-Hose Co., Inc.
   c. Flexicraft Industries.
   d. Flex-Weld, Inc.
   e. Garlock Sealing Technologies.
   f. General Rubber Corporation.
   g. Mason Industries, Inc.; Mercer Rubber Co.
   h. Metraflex, Inc.
   i. Proco Products, Inc.
   j. Red Valve Company, Inc.
   k. Tozen Corporation.
   l. Unaflex.
   m. Unisource Manufacturing, Inc.
2. Standards: ASTM F 1123 and FSA's "Technical Handbook: Non-Metallic Expansion Joints and Flexible Pipe Connectors."
3. Material: Fabric-reinforced rubber complying with FSA-PSJ-703.
4. Arch Type: Single or multiple arches with external control rods.
5. Spherical Type: [Single] [or] [multiple] spheres [with external control rods].
6. Minimum Pressure Rating for NPS 1-1/2 to NPS 4: 150 psig at 220 deg F.
7. Minimum Pressure Rating for NPS 5 and NPS 6: 140 psig at 200 deg F.
8. Minimum Pressure Rating for NPS 8 to NPS 12: 140 psig at 180 deg F.
9. Material for Fluids Containing Acids, Alkalis, or Chemicals: Chlorosulfonylpolyethylene rubber or Ethylene-propylene-diene terpolymer rubber.
10. Material for Fluids Containing Gas, Hydrocarbons, or Oil: Buna-N or Chlorosulfonated polyethylene synthetic rubber.
11. Material for Water: Buna-N or Chlorosulfonated polyethylene synthetic rubber or Natural rubber.
12. End Connections: Full-faced, integral steel flanges with steel retaining rings.

2.3 GROOVED-JOINT EXPANSION JOINTS

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Anvil International Inc.
   b. Shurjoint Piping Products.
   c. Victaulic Company.
2. Description: Factory-assembled expansion joint made of several grooved-end pipe nipples, couplings, and grooved joints.
3. Standard: AWWA C606, for grooved joints.

4. Nipples: Galvanized, ASTM A 53/A 53M, Schedule 40, Type E or S, steel pipe with grooved ends.
5. Couplings: 12, flexible type for steel-pipe dimensions. Include ferrous housing sections, Buna-N gasket suitable for diluted acid, alkaline fluids, and cold and hot water or ethylene-propylene-diene terpolymer rubber gasket suitable for cold and hot water, and bolts and nuts.

2.4 ALIGNMENT GUIDES AND ANCHORS

A. Alignment Guides:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Adsco Manufacturing LLC.
    b. Advances Thermal Systems, Inc.
    c. Flex-Hose Co., Inc.
    f. Flexicraft Industries.
    g. Flex Pression Ltd.
    h. Flex-Weld, Inc.
    i. Hyspan Precision Products, Inc.
    k. Metraflex, Inc.
    l. Proco Products, Inc.
    m. Senior Flexonics Pathway.
    n. U.S. Bellows, Inc.

2. Description: Steel, factory-fabricated alignment guide, with bolted two-section outer cylinder and base for attaching to structure; with two-section guiding slider for bolting to pipe. B. Anchor Materials:

1. Steel Shapes and Plates: ASTM A 36/A 36M.
2. Bolts and Nuts: ASME B18.10 or ASTM A 183, steel hex head.
3. Washers: ASTM F 844, steel, plain, flat washers.
4. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened portland cement concrete, with tension and shear capacities appropriate for application.

    a. Stud: Threaded, zinc-coated carbon steel.
    b. Expansion Plug: Zinc-coated steel.
    c. Washer and Nut: Zinc-coated steel.

5. Chemical Fasteners: Insert-type stud, bonding-system anchor for use with hardened portland cement concrete, with tension and shear capacities appropriate for application.

    a. Bonding Material: ASTM C 881/C 881M, Type IV, Grade 3, twocomponent epoxy resin suitable for surface temperature of hardened concrete where fastener is to be installed.
    b. Stud: ASTM A 307, zinc-coated carbon steel with continuous thread on stud, unless otherwise indicated.

c. Washer and Nut: Zinc-coated steel.

PART 3 - EXECUTION

3.1 EXPANSION JOINT INSTALLATION

A. Install expansion joints of sizes matching sizes of piping in which they are installed.

B. Install packed-type expansion joints with packing suitable for fluid service.

C. Install metal-bellows expansion joints according to EJMA's "Standards of the Expansion Joint Manufacturers Association, Inc."

D. Install rubber packless expansion joints according to FSA-PSJ-703.

E. Install grooved-joint expansion joints to grooved-end steel piping.

3.2 PIPE LOOP AND SWING CONNECTION INSTALLATION

A. Install pipe loops cold-sprung in tension or compression as required to partly absorb tension or compression produced during anticipated change in temperature.

B. Connect risers and branch connections to mains with at least five pipe fittings, including tee in main.

C. Connect risers and branch connections to terminal units with at least four pipe fittings, including tee in riser.

D. Connect mains and branch connections to terminal units with at least four pipe fittings, including tee in main.

3.3 ALIGNMENT-GUIDE AND ANCHOR INSTALLATION

A. Install alignment guides to guide expansion and to avoid end-loading and torsional stress.

B. Install two guide(s) on each side of pipe expansion fittings and loops. Install guides nearest to expansion joint not more than four pipe diameters from expansion joint. C. Attach guides to pipe, and secure guides to building structure.

D. Install anchors at locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.

E. Anchor Attachments:

1. Anchor Attachment to Steel Pipe: Attach by welding. Comply with ASME B31.9 and ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
2. Anchor Attachment to Copper Tubing: Attach with pipe hangers. Use MSS SP69, Type 24; U bolts bolted to anchor.

F. Fabricate and install steel anchors by welding steel shapes, plates, and bars. Comply with ASME B31.9 and AWS D1.1/D1.1M.

1. Anchor Attachment to Steel Structural Members: Attach by welding.
2. Anchor Attachment to Concrete Structural Members: Attach by fasteners. Follow fastener manufacturer's written instructions.

G. Use grout to form flat bearing surfaces for guides and anchors attached to concrete.

END OF SECTION

SECTION 230517
SLEEVES AND SLEEVE SEALS FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Sleeves.
2. Stack-sleeve fittings. 3. Sleeve-seal systems.
4. Sleeve-seal fittings.
5. Grout.
6. Silicone sealants. B. Related Requirements:

1. Section 078413 "Penetration Firestopping" for penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

PART 2 - PRODUCTS

2.1 SLEEVES

A. Cast-Iron Pipe Sleeves: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop collar.

B. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, anticorrosion coated or zinc coated, with plain ends and integral welded waterstop collar.

C. Galvanized-Steel Sheet Sleeves: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

2.2 STACK-SLEEVE FITTINGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Smith, Jay R. Mfg. Co.

2. Zurn Specification Drainage Operation; Zurn Plumbing Products Group.

B. Description: Manufactured, Duco-coated or galvanized cast-iron sleeve with integral cast flashing flange for use in waterproof floors and roofs. Include clamping ring, bolts, and nuts for membrane flashing.

1. Underdeck Clamp: Clamping ring with setscrews.

2.3 SLEEVE-SEAL SYSTEMS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Advance Products & Systems, Inc.
2. CALPICO, Inc.
3. Metraflex Company (The).
4. Pipeline Seal and Insulator, Inc.
5. Proco Products, Inc. B. Description:

1. Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.
2. Designed to form a hydrostatic seal of 20-psig.
3. Sealing Elements: EPDM-rubber or High-temperature-silicone interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size.
4. Pressure Plates: Carbon steel or Stainless steel.
5. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, ASTM B 633 or Stainless steel of length required to secure pressure plates to sealing elements.

2.4 SLEEVE-SEAL FITTINGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Presealed Systems B.

Description:

1. Manufactured plastic, sleeve-type, waterstop assembly, made for imbedding in concrete slab or wall.
2. Plastic or rubber waterstop collar with center opening to match piping OD.

2.5 GROUT

A. Description: Nonshrink, recommended for interior and exterior sealing openings in nonfire-rated walls or floors.

B. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

C. Design Mix: 5000-psi, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

2.6 SILICONE SEALANTS

A. Silicone, S, NS, 25, NT: Single-component, nonsag, plus 25 percent and minus 25 percent movement capability, nontraffic-use, neutral-curing silicone joint sealant, ASTM C 920, Type S, Grade NS, Class 25, use NT.

B. Silicone, S, P, 25, T, NT: Single-component, pourable, plus 25 percent and minus 25 percent movement capability, traffic- and nontraffic-use, neutral-curing silicone joint sealant; ASTM C 920, Type S, Grade P, Class 25, Uses T and NT. Grade P Pourable (self-leveling) formulation is for opening in floors and other horizontal surfaces that are not fire rated.

C. Silicone Foam: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.

B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch annular clear space between piping and concrete slabs and walls.

1. Sleeves are not required for core-drilled holes.

C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.

1. Permanent sleeves are not required for holes in slabs formed by molded-PE or -PP sleeves.
2. Cut sleeves to length for mounting flush with both surfaces.

   a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level.

3. Using grout or silicone sealant, seal space outside of sleeves in slabs and walls without sleeve-seal system.

D. Install sleeves for pipes passing through interior partitions.

1. Cut sleeves to length for mounting flush with both surfaces.
2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
3. Seal annular space between sleeve and piping or piping insulation; use sealants appropriate for size, depth, and location of joint.

E. Fire-Resistance-Rated Penetrations, Horizontal Assembly Penetrations, and SmokeBarrier Penetrations: Maintain indicated fire or smoke rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials. Comply with requirements for firestopping and fill materials specified in Section 078413 "Penetration Firestopping."

3.2 STACK-SLEEVE-FITTING INSTALLATION

A. Install stack-sleeve fittings in new slabs as slabs are constructed.

1. Install fittings that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
2. Secure flashing between clamping flanges for pipes penetrating floors with membrane waterproofing. Comply with requirements for flashing specified in Section 076200 "Sheet Metal Flashing and Trim."
3. Install section of cast-iron soil pipe to extend sleeve to 3 inches above finished floor level.
4. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
5. Using waterproof silicone sealant, seal space between top hub of stack-sleeve fitting and pipe.

B. Fire-Resistance-Rated, Horizontal Assembly, and Smoke Barrier Penetrations: Maintain indicated fire or smoke rating of floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials. Comply with requirements for firestopping specified in Section 078413 "Penetration Firestopping."

3.3 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.

B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal-system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

3.4 SLEEVE-SEAL-FITTING INSTALLATION

A. Install sleeve-seal fittings as new walls and slabs are constructed.

B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall. C. Secure nailing flanges to concrete forms.

D. Using grout or silicone sealant, seal space around outside of sleeve-seal fittings.

3.5 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Leak Test: After allowing for a full cure, test sleeves and sleeve seals for leaks. Repair leaks and retest until no leaks exist.

B. Sleeves and sleeve seals will be considered defective if they do not pass tests and inspections.

3.6 SLEEVE AND SLEEVE-SEAL SCHEDULE

A. Use sleeves and sleeve seals for the following piping-penetration applications:

1. Exterior Concrete Walls Above Grade:

   a. Piping Smaller Than NPS 6: Steel pipe sleeves or Sleeve-seal fittings.
   b. Piping NPS 6 and Larger: Steel pipe sleeves or Sleeve-seal fittings.

2. Exterior Concrete Walls Below Grade:
   a. Piping Smaller Than NPS 6: Steel pipe sleeves with sleeve-seal system or Sleeve-seal fittings.

      1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

b. Piping NPS 6 and Larger: Steel pipe sleeves with sleeve-seal system or Sleeve-seal fittings.

1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

3. Concrete Slabs-on-Grade:

a. Piping Smaller Than NPS 6: Steel pipe sleeves with sleeve-seal system or Sleeve-seal fittings].

1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

b. Piping NPS 6 and Larger: Steel pipe sleeves with sleeve-seal system or Sleeve-seal fittings.

1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

4. Concrete Slabs Above Grade:

a. Piping Smaller Than NPS 6: Steel pipe sleeves or Stack-sleeve fittings or Sleeve-seal fittings.
b. Piping NPS 6 and Larger: Steel pipe sleeves or Stack-sleeve fittings.

5. Interior Partitions:

a. Piping Smaller Than NPS 6: .Steel pipe sleeves.
b. Piping NPS 6 and Larger: Galvanized-steel sheet sleeves.

END OF SECTION

SECTION 230518
ESCUTCHEONS FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Escutcheons.
2. Floor plates.

1.3 DEFINITIONS

A. Existing Piping to Remain: Existing piping that is not to be removed and that is not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 ESCUTCHEONS

A. One-Piece, Steel Type: With polished, chrome-plated or polished brass finish and setscrew fastener.

B. One-Piece, Stainless-Steel Type: With polished stainless-steel finish.

C. One-Piece, Cast-Brass Type: With polished, chrome-plated or polished brass finish and setscrew fastener.

D. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped steel or brass with polished, chrome-plated finish and spring-clip fasteners.

E. One-Piece, Stamped-Steel Type: With polished, chrome-plated finish and springclip fasteners.

F. Split-Plate, Stamped-Steel Type: With polished, chrome-plated finish; concealed and exposed-rivet hinge; and spring-clip fasteners.

2.2 FLOOR PLATES

A. Split Floor Plates: Steel with concealed hinge.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.

B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

1. Escutcheons for New Piping[**and Relocated Existing Piping**]:

   a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep pattern.
   b. Chrome-Plated Piping: One-piece steel, cast brass or split-plate steel with polished, chrome-plated finish.
   c. Insulated Piping: One-piece steel with polished, chrome-plated or polished brass finish.
   d. Insulated Piping: One-piece stainless steel with polished stainless-steel finish.
   e. Insulated Piping: One-piece cast brass with polished, chrome-plated or polished brass finish.
   f. Insulated Piping: One-piece stamped steel or split-plate, stamped steel with concealed hinge or split-plate, stamped steel with exposed-rivet hinge with polished, chrome-plated finish.
   g. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Onepiece steel with polished, chrome-plated or polished brass finish.
   h. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Onepiece stainless steel with polished stainless-steel finish.
   i. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Onepiece cast brass with polished, chrome-plated or polished brass finish.
   j. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Onepiece stamped steel or split-plate, stamped steel with concealed hinge or split-plate, stamped steel with exposed-rivet hinge with polished, chrome-plated finish.
   k. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece steel with polished, chrome-plated or polished brass finish.

l. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece stainless steel with polished stainless-steel finish.
m. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece cast brass with polished, chrome-plated or polished brass finish.
n. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece stamped steel or split-plate, stamped steel with concealed hinge or split-plate, stamped steel with exposed-rivet hinge with polished, chrome-plated finish.
o. Bare Piping in Unfinished Service Spaces: One-piece steel with polished, chrome-plated finish.
p. Bare Piping in Unfinished Service Spaces: One-piece cast brass with polished, chrome-plated or rough-brass finish.
q. Bare Piping in Unfinished Service Spaces: One-piece stamped steel or split-plate, stamped steel with concealed hinge or split-plate, stamped steel with exposed-rivet hinge with polished, chrome-plated finish.
r. Bare Piping in Equipment Rooms: One-piece steel with polished, chrome-plated finish.
s. Bare Piping in Equipment Rooms: One-piece cast brass with polished, chrome-plated or rough-brass finish.
t. Bare Piping in Equipment Rooms: One-piece stamped steel or splitplate, stamped steel with concealed hinge or split-plate, stamped steel with exposed-rivet hinge with polished, chrome-plated finish.

2. Escutcheons for Existing Piping to Remain:

a. Chrome-Plated Piping: Split-plate, stamped steel with concealed or exposed-rivet hinge with polished, chrome-plated finish.
b. Insulated Piping: Split-plate, stamped steel with concealed or exposedrivet hinge with polished, chrome-plated finish.
c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Splitplate, stamped steel with concealed or exposed-rivet hinge with polished, chrome-plated finish.
d. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-plate, stamped steel with concealed or exposed-rivet hinge with polished, chrome-plated finish.
e. Bare Piping in Unfinished Service Spaces: Split-plate, stamped steel with concealed or exposed-rivet hinge with polished, chrome-plated finish.
f. Bare Piping in Equipment Rooms: Split-plate, stamped steel with concealed or exposed-rivet hinge with polished, chrome-plated finish. C.

Install floor plates for piping penetrations of equipment-room floors.

D. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

1. New Piping and Existing Piping: Split floor plate.
2. Existing Piping to Remain: Split floor plate.

3.2 FIELD QUALITY CONTROL

A. Using new materials, replace broken and damaged escutcheons and floor plates.

END OF SECTION

SECTION 230519
METERS AND GAGES FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Bimetallic-actuated thermometers.
2. Filled-system thermometers.
3. Liquid-in-glass thermometers.
4. Light-activated thermometers.
5. Duct-thermometer mounting brackets.
6. Thermowells.
7. Dial-type pressure gages.
8. Gage attachments.
9. Test plugs.
10. Test-plug kits.
11. Sight flow indicators.
12. Flowmeters.

B. Related Requirements:

1. Section 231123 "Facility Natural-Gas Piping" for gas meters.
2. Section 232216 "Steam and Condensate Piping Specialties" for steam and condensate meters.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each type of meter and gage.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For meters and gages to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 BIMETALLIC-ACTUATED THERMOMETERS

A. A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Ashcroft Inc.
2. Ernst Flow Industries.
3. Marsh Bellofram.
4. Miljoco Corporation.
5. Nanmac Corporation.
6. Noshok.
7. Palmer Wahl Instrumentation Group.
8. REOTEMP Instrument Corporation.
9. Tel-Tru Manufacturing Company.
10. Trerice, H. O. Co.
11. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
12. Weiss Instruments, Inc.
13. WIKA Instrument Corporation - USA.
14. Winters Instruments - U.S. B. Standard: ASME B40.200.

C. Case: Liquid-filled and sealed type(s); stainless steel with 3-inch or 5-inch nominal diameter.

D. Dial: Nonreflective aluminum with permanently etched scale markings and scales in deg F.

E. Connector Type(s): Union joint, adjustable angle, rigid, back and rigid, bottom, with unified-inch screw threads.

F. Connector Size: 1/2 inch, with ASME B1.1 screw threads.

G. Stem: 0.25 or 0.375 inch in diameter; stainless steel.

H. Window: Plain glass or plastic.

I. Ring: Stainless steel.

J. Element: Bimetal coil.

K. Pointer: Dark-colored metal.

2.2 FILLED-SYSTEM THERMOMETERS

A. Direct-Mounted, Metal-Case, Vapor-Actuated Thermometers:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following: a. Ashcroft Inc.
    b. Ernst Flow Industries.
    c. Marsh Bellofram.
    d. Miljoco Corporation.
    e. Nanmac Corporation.
    f. Noshok.
    g. Palmer Wahl Instrumentation Group.
    h. REOTEMP Instrument Corporation.
    i. Tel-Tru Manufacturing Company.
    j. Trerice, H. O. Co.
    k. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
    l. Weiss Instruments, Inc.
    m. WIKA Instrument Corporation - USA.
    n. Winters Instruments - U.S.
2. Standard: ASME B40.200.
3. Case: Sealed type, [cast aluminum or drawn steel] <Insert material>; [41/2-inch (114-mm)] [5-inch (127-mm)] [6-inch (152-mm)] <Insert dimension> nominal diameter.
4. Element: Bourdon tube or other type of pressure element.
5. Movement: Mechanical, dampening type, with link to pressure element and connection to pointer.
6. Dial: Nonreflective aluminum with permanently etched scale markings graduated in deg F.
7. Pointer: Dark-colored metal.
8. Window: Glass or plastic.
9. Ring: Metal or Stainless steel.
10. Connector Type(s): Union joint, adjustable, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device, rigid, back and rigid, bottom; with ASME B1.1 screw threads.
11. Thermal System: Liquid-filled bulb in copper-plated steel, aluminum, or brass stem and of length to suit installation.

    a. Design for Air-Duct Installation: With ventilated shroud.
    b. Design for Thermowell Installation: Bare stem.

12. Accuracy: Plus or minus 1 percent of scale range.

B. Direct-Mounted, Plastic-Case, Vapor-Actuated Thermometers:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following: a. Ashcroft Inc.
    b. Miljoco Corporation.
    c. REOTEMP Instrument Corporation.
2. Standard: ASME B40.200.

3. Case: Sealed type, plastic; 4-1/2-inch or 6-inch nominal diameter.
4. Element: Bourdon tube or other type of pressure element.
5. Movement: Mechanical, with link to pressure element and connection to pointer.
6. Dial: Nonreflective aluminum with permanently etched scale markings graduated in deg F.
7. Pointer: Dark-colored metal.
8. Window: Glass or plastic.
9. Ring: Metal or plastic.
10. Connector Type(s): Union joint, adjustable, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device, rigid, back and rigid, bottom; with ASME B1.1 screw threads.
11. Thermal System: Liquid-filled bulb in copper-plated steel, aluminum, or brass stem and of length to suit installation.

    a. Design for Air-Duct Installation: With ventilated shroud.
    b. Design for Thermowell Installation: Bare stem.

12. Accuracy: Plus or minus 1 percent of scale range.

C. Remote-Mounted, Metal-Case, Vapor-Actuated Thermometers:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. AMETEK, Inc.; U.S. Gauge.
    b. Ashcroft Inc.
    c. Marsh Bellofram.
    d. Miljoco Corporation.
    e. Palmer Wahl Instrumentation Group.
    f. REOTEMP Instrument Corporation.
    g. Trerice, H. O. Co.
    h. Weiss Instruments, Inc.
    i. WIKA Instrument Corporation - USA.
2. Standard: ASME B40.200.
3. Case: Sealed type, cast aluminum or drawn steel; 4-1/2-inch or 6-inch nominal diameter with back or front flange and holes for panel mounting.
4. Element: Bourdon tube or other type of pressure element.
5. Movement: Mechanical, with link to pressure element and connection to pointer.
6. Dial: Nonreflective aluminum with permanently etched scale markings graduated in deg F.
7. Pointer: Dark-colored metal.
8. Window: Glass or plastic.
9. Ring: Metal or Stainless steel.
10. Connector Type(s): Union joint, back or bottom; with ASME B1.1 screw threads.
11. Thermal System: Liquid-filled bulb in copper-plated steel, aluminum, or brass stem and of length to suit installation.

    a. Design for Air-Duct Installation: With ventilated shroud.
    b. Design for Thermowell Installation: Bare stem.

12. Accuracy: Plus or minus 1 percent of scale range.

2.3 LIQUID-IN-GLASS THERMOMETERS

A. Metal-Case, Compact-Style, Liquid-in-Glass Thermometers:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following: a. Trerice, H. O. Co.
   2. Standard: ASME B40.200.
   3. Case: Cast aluminum; 6-inch nominal size.
   4. Case Form: Back angle or Straight unless otherwise indicated.
   5. Tube: Glass with magnifying lens and blue or red organic liquid.
   6. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F.
   7. Window: Glass or plastic.
   8. Stem: Aluminum or brass and of length to suit installation.
      a. Design for Air-Duct Installation: With ventilated shroud.
      b. Design for Thermowell Installation: Bare stem.
   9. Connector: 3/4 inch, with ASME B1.1 screw threads.
   10. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

B. Plastic-Case, Compact-Style, Liquid-in-Glass Thermometers:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following: a. Flo Fab Inc.
      b. Miljoco Corporation.
      c. Tel-Tru Manufacturing Company.
      d. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
      e. Weiss Instruments, Inc.
      f. WIKA Instrument Corporation - USA.
   2. Standard: ASME B40.200.
   3. Case: Plastic; 6-inch nominal size.
   4. Case Form: Back angle or Straight unless otherwise indicated.
   5. Tube: Glass with magnifying lens and blue or red organic liquid.
   6. Tube Background: Nonreflective with permanently etched scale markings graduated in deg F.
   7. Window: Glass or plastic.
   8. Stem: Aluminum or brass and of length to suit installation.
      a. Design for Air-Duct Installation: With ventilated shroud.
      b. Design for Thermowell Installation: Bare stem.
   9. Connector: 3/4 inch, with ASME B1.1 screw threads.
   10. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

C. Metal-Case, Industrial-Style, Liquid-in-Glass Thermometers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following: a. Flo Fab Inc.
    - b. Miljoco Corporation.
    - c. Palmer Wahl Instrumentation Group.
    - d. Tel-Tru Manufacturing Company.
    - e. Treriece, H.O. Co.
    - f. Weiss Instruments, Inc.
    - g. Winters Instruments- U.S.
2. Standard: ASME B40.200.
3. Case: Cast aluminum; 7-inch or 9-inch nominal size unless otherwise indicated.
4. Case Form: Adjustable angle, Back angle or Straight unless otherwise indicated.
5. Tube: Glass with magnifying lens and blue or red organic liquid.
6. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F.
7. Window: Glass or plastic.
8. Stem: Aluminum and of length to suit installation.

    - a. Design for Air-Duct Installation: With ventilated shroud.
    - b. Design for Thermowell Installation: Bare stem.

9. Connector: 1-1/4 inches, with ASME B1.1 screw threads.
10. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

D. Plastic-Case, Industrial-Style, Liquid-in-Glass Thermometers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Ernst Flow Industries.
    - b. Marsh Bellofram.
    - c. Miljoco Corporation.
    - d. Palmer Wahl Instrumentation Group.
    - e. REOTEMP Instrument Corporation.
    - f. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
    - g. Weiss Instruments, Inc.
    - h. WIKA Instrument Corporation - USA.
2. Standard: ASME B40.200.
3. Case: Plastic; 7-inch or 9-inch nominal size unless otherwise indicated.
4. Case Form: Adjustable angle, Back angle or Straight unless otherwise indicated.
5. Tube: Glass with magnifying lens and blue [or red] organic liquid.
6. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F.
7. Window: Glass or plastic.
8. Stem: Aluminum, Brass, Stainless steel, [Aluminum, brass, or stainless steel and of length to suit installation.

    - a. Design for Air-Duct Installation: With ventilated shroud.
    - b. Design for Thermowell Installation: Bare stem.

9. Connector: 1-1/4 inches with ASME B1.1 screw threads.
10. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

2.4 DUCT-THERMOMETER MOUNTING BRACKETS

A. Description: Flanged bracket with screw holes, for attachment to air duct and made to hold thermometer stem.

2.5 THERMOWELLS

A. Thermowells:

1. Standard: ASME B40.200.
2. Description: Pressure-tight, socket-type fitting made for insertion in piping tee fitting.
3. Material for Use with Copper Tubing:[CNR or CUNI.
4. Material for Use with Steel Piping: CRES or CSA.
5. Type: Stepped shank unless straight or tapered shank is indicated.
6. External Threads: NPS 1/2, NPS 3/4, or NPS 1, ASME B1.20.1 pipe threads.
7. Internal Threads: 1/2, 3/4, and 1 inch, with ASME B1.1 screw threads.
8. Bore: Diameter required to match thermometer bulb or stem.
9. Insertion Length: Length required to match thermometer bulb or stem.
10. Lagging Extension: Include on thermowells for insulated piping and tubing.
11. Bushings: For converting size of thermowell's internal screw thread to size of thermometer connection.

B. Heat-Transfer Medium: Mixture of graphite and glycerin.

2.6 DIAL-TYPE PRESSURE GAGES

A. Direct-Mounted, Metal-Case, Dial-Type Pressure Gages:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. AMETEK, Inc.; U.S. Gauge.
   b. Ashcroft Inc.
   c. Ernst Flow Industries.
   d. Flo Fab Inc.
   e. Marsh Bellofram.
   f. Miljoco Corporation.
   g. Noshok.
   h. Palmer Wahl Instrumentation Group.
   i. REOTEMP Instrument Corporation.
   j. Tel-Tru Manufacturing Company.
   k. Trerice, H. O. Co.

l. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
m. Weiss Instruments, Inc.
n. WIKA Instrument Corporation - USA.
o. Winters Instruments - U.S.

2. Standard: ASME B40.100.
3. Case: Liquid-filled or Sealed; 4-1/2-inch or 6-inch nominal diameter.
4. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
5. Pressure Connection: Brass, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
6. Movement: Mechanical, with link to pressure element and connection to pointer.
7. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi.
8. Pointer: Dark-colored metal.
9. Window: Glass or plastic.
10. Ring: Metal, Brass or Stainless steel.
11. Accuracy: Grade A, plus or minus 1 percent of middle half of] [Grade B, plus or minus 2 percent of middle half of, Grade C, plus or minus 3 percent of middle half of or Grade D, plus or minus 5 percent of whole scale range.

B. Direct-Mounted, Plastic-Case, Dial-Type Pressure Gages:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. AMETEK, Inc.; U.S. Gauge.
   b. Ashcroft Inc.
   c. Flo Fab Inc.
   d. Marsh Bellofram.
   e. Miljoco Corporation.
   f. Noshok.
   g. Palmer Wahl Instrumentation Group.
   h. REOTEMP Instrument Corporation.
   i. Tel-Tru Manufacturing Company.
   j. Trerice, H. O. Co.
   k. Weiss Instruments, Inc.
   l. WIKA Instrument Corporation - USA.
   m. Winters Instruments - U.S.
2. Standard: ASME B40.100.
3. Case: Sealed type; plastic 4-1/2-inch or 6-inch nominal diameter.
4. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
5. Pressure Connection: Brass, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
6. Movement: Mechanical, with link to pressure element and connection to pointer.
7. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi.
8. Pointer: Dark-colored metal.
9. Window: Glass or plastic.

10. Accuracy: Grade A, plus or minus 1 percent of middle half of, Grade B, plus or minus 2 percent of middle half of, or Grade C, plus or minus 3 percent of middle half of, Grade D, plus or minus 5 percent of whole]scale range.

2.7 GAGE ATTACHMENTS

A. Snubbers: ASME B40.100, brass; with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and piston or porous-metal-type surge-dampening device. Include extension for use on insulated piping.

B. Siphons: Loop-shaped section of brass or stainless-steel, steel pipe with NPS 1/4 or NPS ½ pipe threads.

C. Valves: Brass ball, Brass or stainless-steel needle, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads.

2.8 TEST PLUGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Flow Design, Inc.
   b. Miljoco Corporation.
   c. National Meter, Inc.
   d. Peterson Equipment Co., Inc.
   e. Sisco Manufacturing Company, Inc.
   f. Trerice, H. O. Co.
   g. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
   h. Weiss Instruments, Inc.

B. Description: Test-station fitting made for insertion in piping tee fitting.

C. Body: Brass or stainless steel with core inserts and gasketed and threaded cap. Include extended stem on units to be installed in insulated piping. D. Thread Size: NPS ¼ or NPS 1/2, ASME B1.20.1 pipe thread.

E. Minimum Pressure and Temperature Rating: 500 psig at 200 deg F.

F. Core Inserts: Chlorosulfonated polyethylene synthetic and EPDM self-sealing rubber.

2.9 TEST-PLUG KITS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Flow Design, Inc.
   b. Miljoco Corporation.
   c. National Meter, Inc.

d. Peterson Equipment Co., Inc.
e. Sisco Manufacturing Company, Inc.
f. Trerice, H. O. Co.
g. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
h. Weiss Instruments, Inc.

B. Furnish one test-plug kit(s) containing one or two thermometer(s), one pressure gage and adapter, and carrying case. Thermometer sensing elements, pressure gage, and adapter probes shall be of diameter to fit test plugs and of length to project into piping.

C. Low-Range Thermometer: Small, bimetallic insertion type with 1- to 2-inch diameter dial and tapered-end sensing element. Dial range shall be at least 25 to 125 deg F.

D. High-Range Thermometer: Small, bimetallic insertion type with 1- to 2-inch diameter dial and tapered-end sensing element. Dial range shall be at least 0 to 220 deg F.

E. Pressure Gage: Small, Bourdon-tube insertion type with 2- to 3-inc] diameter dial and probe. Dial range shall be at least 0 to 200 psig.

F. Carrying Case: Metal or plastic, with formed instrument padding.

2.10 SIGHT FLOW INDICATORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Archon Industries, Inc.
b. Dwyer Instruments, Inc.
c. Emerson Process Management; Brooks Instrument.
d. Ernst Co., John C., Inc.
e. Ernst Flow Industries.
f. KOBOLD Instruments, Inc. - USA; KOBOLD Messring GmbH.
g. OPW Engineered Systems; a Dover company.
h. Penberthy; A Brand of Tyco Valves & Controls - Prophetstown. B.

Description: Piping inline-installation device for visual verification of

flow.

C. Construction: Bronze or stainless-steel body, with sight glass and ball, flapper, or paddle wheel indicator, and threaded or flanged ends. D. Minimum Pressure Rating: 150 psig.

E. Minimum Temperature Rating: 200 deg F.

F. End Connections for NPS 2 and Smaller: Threaded.

G. End Connections for NPS 2-1/2) and Larger: Flanged.

2.11 FLOWMETERS

A. Orifice Flowmeters:

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

a.
b.
ABB; Instrumentation and Analytical. Bell & Gossett; ITT Industries.
c. Meriam Process Technologies.
d. Preso Meters; a division of Racine Federated Inc.
e. S. A. Armstrong Limited; Armstrong Pumps Inc.

2. Description: Flowmeter with sensor, hoses or tubing, fittings, valves, indicator, and conversion chart.
3. Flow Range: Sensor and indicator shall cover operating range of equipment or system served.
4. Sensor: Wafer-orifice-type, calibrated, flow-measuring element; for installation between pipe flanges.

a. Design: Differential-pressure-type measurement for steam and water.
b. Construction: Cast-iron body, brass valves with integral check valves and caps, and calibrated nameplate.
c. Minimum Pressure Rating: 300 psig.
d. Minimum Temperature Rating: 250 deg F.

5. Permanent Indicators: Meter suitable for wall or bracket mounting, calibrated for connected sensor and having 6-inch- diameter, or equivalent, dial with fittings and copper tubing for connecting to sensor.

a. Scale: Gallons per minute.
b. Accuracy: Plus or minus 1 percent between 20 and 80 percent of scale range.

6. Portable Indicators: Hand-held, differential-pressure type, calibrated for connected sensor and having two 12-foot hoses, with carrying case.

a. Scale: Gallons per minute.
b. Accuracy: Plus or minus 2 percent between 20 and 80 percent of scale range.

7. Display: Shows rate of flow, with register to indicate total volume in gallons.
8. Conversion Chart: Flow rate data compatible with sensor and indicator.
9. Operating Instructions: Include complete instructions with each flowmeter.

B. Pitot-Tube Flowmeters:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. ABB; Instrumentation and Analytical.
b. Emerson Process Management; Rosemount.
c. Meriam Process Technologies.
d. Preso Meters; a division of Racine Federated Inc.
e. TACO Incorporated.
f. Veris Industries, Inc.

a.
b.

2. Description: Flowmeter with sensor and indicator.
3. Flow Range: Sensor and indicator shall cover operating range of equipment or system served.
4. Sensor: Insertion type; for inserting probe in piping and measuring flow directly in gallons per minute.
   Design: Differential-pressure-type measurement for water.
   Construction: Stainless-steel probe of length to span inside of pipe, with integral transmitter and direct-reading scale.
   c. Minimum Pressure Rating: 150 psig.
   d. Minimum Temperature Rating: 250 deg F.
5. Indicator: Hand-held meter; either an integral part of sensor or a separate meter.
6. Integral Transformer: For low-voltage power connection.
7. Accuracy: Plus or minus 3 percent.
8. Display: Shows rate of flow**,** with register to indicate total volume in gallons.
9. Operating Instructions: Include complete instructions with each flowmeter.

C. Venturi Flowmeters:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. ABB; Instrumentation and Analytical.
   b. Gerand Engineering Co.
   c. Hyspan Precision Products, Inc.
   d. Preso Meters; a division of Racine Federated Inc.
   e. S. A. Armstrong Limited; Armstrong Pumps Inc.
   f. Victaulic Company.
2. Description: Flowmeter with calibrated flow-measuring element, hoses or tubing, fittings, valves, indicator, and conversion chart.
3. Flow Range: Sensor and indicator shall cover operating range of equipment or system served.
4. Sensor: Venturi-type, calibrated, flow-measuring element; for installation in piping.
   a. Design: Differential-pressure-type measurement for steam and water.
   b. Construction: Bronze, brass, or factory-primed steel, with brass fittings and attached tag with flow conversion data.
   c. Minimum Pressure Rating: 250 psi].
   d. Minimum Temperature Rating: 250 deg.
   e. End Connections for NPS 2 and Smaller: Threaded.
   f. End Connections for NPS 2-1/2 and Larger: Flanged or welded.
   g. Flow Range: Flow-measuring element and flowmeter shall cover operating range of equipment or system served.

a.
b.

5. Permanent Indicators: Meter suitable for wall or bracket mounting, calibrated for connected flowmeter element, and having 6-inch- diameter, or equivalent, dial with fittings and copper tubing for connecting to flowmeter element.

    a. Scale: Gallons per minute.
    b. Accuracy: Plus or minus 1 percent between 20 and 80 percent of scale range.

6. Portable Indicators: Hand-held, differential-pressure type, calibrated for connected flowmeter element and having two 12-foot hoses, with carrying case.
    Scale: Gallons per minute.
    Accuracy: Plus or minus 2 percent between 20 and 80 percent of scale range.

7. Display: Shows rate of flow, with register to indicate total volume in gallons.
8. Conversion Chart: Flow rate data compatible with sensor.
9. Operating Instructions: Include complete instructions with each flowmeter.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install thermowells with socket extending a minimum of 2 inches into fluid or onethird of pipe diameter to center of pipe and in vertical position in piping tees.

B. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.

C. Install thermowells with extension on insulated piping.

D. Fill thermowells with heat-transfer medium.

E. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.

F. Install remote-mounted thermometer bulbs in thermowells and install cases on panels; connect cases with tubing and support tubing to prevent kinks. Use minimum tubing length.

G. Install duct-thermometer mounting brackets in walls of ducts. Attach to duct with screws.

H. Install direct-mounted pressure gages in piping tees with pressure gage located on pipe at the most readable position.

a.
b.

I. Install remote-mounted pressure gages on panel.

J. Install valve and snubber in piping for each pressure gage for fluids (except steam).

K. Install valve and syphon fitting in piping for each pressure gage for steam.

L. Install test plugs in piping tees.

M. Install flow indicators in piping systems in accessible positions for easy viewing.

N. Assemble and install connections, tubing, and accessories between flow-measuring elements and flowmeters according to manufacturer's written instructions. O. Install flowmeter elements in accessible positions in piping systems.

P. Install wafer-orifice flowmeter elements between pipe flanges.

Q. Install differential-pressure-type flowmeter elements, with at least minimum straight lengths of pipe, upstream and downstream from element according to manufacturer's written instructions.

R. Install permanent indicators on walls or brackets in accessible and readable positions.

S. Install connection fittings in accessible locations for attachment to portable indicators.

T. Mount thermal-energy meters on wall if accessible; if not, provide brackets to support meters.

U. Install thermometers in the following locations:

1. Inlet and outlet of each hydronic zone.
2. Inlet and outlet of each hydronic boiler.
3. Two inlets and two outlets of each chiller.
4. Inlet and outlet of each hydronic coil in air-handling units.
5. Two inlets and two outlets of each hydronic heat exchanger.
6. Inlet and outlet of each thermal-storage tank.
7. Outside-, return-, supply-, and mixed-air ducts. V. Install

pressure gages in the following locations:

1. Discharge of each pressure-reducing valve.
2. Inlet and outlet of each chiller chilled-water and condenser-water connection.
3. Suction and discharge of each pump.

3.2 CONNECTIONS

A. Install meters and gages adjacent to machines and equipment to allow space for service and maintenance of meters, gages, machines, and equipment. B. Connect flowmeter-system elements to meters.

C. Connect flowmeter transmitters to meters.

3.3 ADJUSTING

A. After installation, calibrate meters according to manufacturer's written instructions.

B. Adjust faces of meters and gages to proper angle for best visibility.

3.4 THERMOMETER SCHEDULE

A. Thermometers at inlet and outlet of each hydronic zone shall be one of the following:

1. Liquid-filled or Sealed, bimetallic-actuated type.
2. Direct-mounted, metal or plastic-case, vapor-actuated type.
3. Compact or Industrial-style, liquid-in-glass type.
4. Direct-mounted, light-activated type.
5. Test plug with chlorosulfonated polyethylene synthetic or EPDM self-sealing rubber inserts.

B. Thermometers at inlet and outlet of each hydronic boiler shall be one of the following:

1. Liquid-filled or Sealed, bimetallic-actuated type.
2. Direct-mounted, metal or plastic-case, vapor-actuated type.
3. Compact or Industrial-style, liquid-in-glass type.
4. Direct-mounted, light-activated type.
5. Test plug with chlorosulfonated polyethylene synthetic or EPDM self-sealing rubber inserts.

C. Thermometers at inlets and outlets of each chiller shall be one of the following:

1. Liquid-filled or Sealed, bimetallic-actuated type.
2. Direct-mounted, metal or plastic-case, vapor-actuated type.
3. Compact or Industrial-style, liquid-in-glass type.
4. Direct-mounted, light-activated type.
5. Test plug with chlorosulfonated polyethylene synthetic or EPDM self-sealing rubber inserts.

D. Thermometers at inlet and outlet of each hydronic coil in air-handling units and built-up central systems shall be one of the following:

1. Liquid-filled or Sealed, bimetallic-actuated type.
2. Direct-mounted, metal or plastic-case, vapor-actuated type.
3. Compact or Industrial-style, liquid-in-glass type.
4. Direct-mounted, light-activated type.
5. Test plug with chlorosulfonated polyethylene synthetic or EPDM self-sealing rubber inserts.

E. Thermometers at inlets and outlets of each hydronic heat exchanger shall be one of the following:

1. Liquid-filled or Sealed, bimetallic-actuated type.
2. Direct-mounted, metal or plastic-case, vapor-actuated type.
3. Compact or Industrial-style, liquid-in-glass type.
4. Direct-mounted, light-activated type.
5. Test plug with chlorosulfonated polyethylene synthetic or EPDM self-sealing rubber inserts.

F. Thermometers at inlet and outlet of each hydronic heat-recovery unit shall be one of the following:

1. Liquid-filled or Sealed, bimetallic-actuated type.
2. Direct-mounted, metal or plastic-case, vapor-actuated type.
3. Compact or Industrial-style, liquid-in-glass type.
4. Direct-mounted, light-activated type.

5. Test plug with chlorosulfonated polyethylene synthetic or EPDM self-sealing rubber inserts.

G. Thermometers at inlet and outlet of each thermal-storage tank shall be one of the following:
1. Liquid-filled or Sealed, bimetallic-actuated type.
2. Direct-mounted, metal or plastic-case, vapor-actuated type.
3. Compact or Industrial-style, liquid-in-glass type.
4. Direct-mounted, light-activated type.
5. Test plug with chlorosulfonated polyethylene synthetic or EPDM self-sealing rubber inserts.

H. Thermometers at outside-, return-, supply-, and mixed-air ducts shall be one of the following:
1. Liquid-filled or Sealed, bimetallic-actuated type.
2. Direct-mounted, metal or plastic-case, vapor-actuated type.
3. Compact or Industrial-style, liquid-in-glass type.
4. Direct-mounted, light-activated type.

I. Thermometer stems shall be of length to match thermowell insertion length.

3.5 THERMOMETER SCALE-RANGE SCHEDULE

A. Scale Range for Chilled-Water Piping: 0 to 100 deg F.

B. Scale Range for Heating, Hot-Water Piping: 30 to 240 deg F.

C. Retain one or more of first four paragraphs below. If retaining more than one scale range, indicate location of each on Drawings.

D. Scale Range for Steam and Steam-Condensate Piping: 0 to 250 deg F.

E. Scale Range for Steam and Steam-Condensate Piping: 50 to 400 deg F.

F. Scale Range for Air Ducts: Minus 40 to plus 160 deg F.

3.6 PRESSURE-GAGE SCHEDULE

A. Pressure gages at discharge of each pressure-reducing valve shall be one of the following:

1. Liquid-filled or Sealed, direct-mounted, metal case.
2. Sealed or direct-mounted, plastic case.
3. Test plug with chlorosulfonated polyethylene synthetic or EPDM self-sealing rubber inserts.

B. Pressure gages at inlet and outlet of each chiller chilled-water and condenser-water connection shall be one of the following:
   1. Liquid-filled or Sealed, direct-mounted, metal case.
   2. Sealed or direct-mounted, plastic case.
   3. Test plug with chlorosulfonated polyethylene synthetic or EPDM self-sealing rubber inserts.

C. Pressure gages at suction and discharge of each pump shall be one of the following:
   1. Liquid-filled or Sealed, direct-mounted, metal case.
   2. Sealed or direct-mounted, plastic case.
   3. Test plug with chlorosulfonated polyethylene synthetic or EPDM self-sealing rubber inserts.

3.7 PRESSURE-GAGE SCALE-RANGE SCHEDULE

A. Scale Range for Chilled-Water Piping: 0 to 300 psi.

B. Scale Range for Heating, Hot-Water Piping: 0 to 200 psi.

C. Scale Range for Steam Piping: 30-in. Hg to 15 psi.

D. Scale Range for Steam Piping: 0 to 160 psi.

3.8 FLOWMETER SCHEDULE

A. Flowmeters for Chilled-Water Piping: Orifice, Pitot-tube or Venturi type.

B. Flowmeters for Heating, Hot-Water Piping: Orifice, Pitot-tube or Venturi type.

C. Flowmeters for Steam and Steam-Condensate Piping: Orifice, Pitot-tube or Venturi type.

END OF SECTION

SECTION 230523
GENERAL-DUTY VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Certain requirements common to all the mechanical and electrical trades (Fire Suppression, Plumbing, HVAC, Electrical, and Tele/Data) are specified in Division 20. To avoid repetition, they are not repeated in each relevant Division of the Specifications. However, these requirements are applicable to the work of this Division, and are hereby incorporated by reference.

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

1.2 SUMMARY

A. Section Includes:

1. Bronze ball valves.
2. Stainless steel ball valves (Clean Steam)
3. Iron, general service butterfly valves.
4. Carbon Steel High-performance butterfly valves.
5. Bronze silent check valves.
6. Iron globe silent check valves.
7. Bronze swing-check valves.
8. Iron swing-check valves.
9. Bronze gate valves.
10. Iron gate valves.
11. Bronze globe valves.

12. Iron globe valves.
13. Eccentric plug valves.
14. Strainers.
15. Vacuum Breakers.
16. Chainwheels.

1.3 DEFINITIONS

RETAIN DEFINITION(S) REMAINING AFTER THIS SECTION HAS BEEN EDITED. A.

CWP: Cold working pressure.

B. EPDM: Ethylene propylene copolymer rubber.

C. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.

D. NRS: Nonrising stem.

E. OS&Y: Outside screw and yoke.

F. RS: Rising stem.

G. SWP: Steam working pressure.

H. PTFE: Polytetrafluoroethylene

I. TFE: Tetrafluoroethylene

1.4 SUBMITTALS

PARAGRAPH BELOW IS DEFINED IN DIVISION 01 SECTION "SUBMITTAL PROCEDURES" AS AN "ACTION SUBMITTAL."

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

1.5 QUALITY ASSURANCE

A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer. B. ASME Compliance:

1. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
2. ASME B31.1 for power piping valves.
3. ASME B31.9 for building services piping valves.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

1. Protect internal parts against rust and corrosion.
2. Protect threads, flange faces, grooves, and weld ends.
3. Set angle, gate, and globe valves closed to prevent rattling.
4. Set ball and plug valves open to minimize exposure of functional surfaces.
5. Set butterfly valves closed or slightly open.
6. Block check valves in either closed or open position. B. Use the following precautions during storage:

1. Maintain valve end protection.
2. Store valves indoors and maintain at higher than ambient dew point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

A. Refer to HVAC valve tables in Part 3 below for applications of valves. Valves of similar type shall be by single manufacturer.

B. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures. Valves shall have name of manufacturer and guaranteed working pressure cast or stamped on bodies. Gaskets and packings shall not contain asbestos.

C. Valve Sizes: Same as upstream piping unless otherwise indicated.

D. Valve Actuator Types:

1. Gear Actuator: For quarter-turn valves NPS 8 and larger.
2. Handwheel: For valves other than quarter-turn types.
3. Handlever: For quarter-turn valves NPS 6 and smaller except plug valves.
4. Wrench: For plug valves with square heads. Furnish Owner with 1 wrench for every 5 plug valves, for each size square plug-valve head.

5. Chainwheel: Device for attachment to valve handwheel, stem, or other actuator; of size and with chain for mounting height, as indicated in the "Valve Installation" Article.

E. Valves in Insulated Piping: With 2-inch stem extensions and the following features:

1. Gate Valves: With rising stem.
2. Ball Valves: With extended operating handle of non-thermal-conductive material, and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation.
3. Butterfly Valves: With extended neck. F. Valve-End Connections:

1. Flanged: With flanges according to ASME B16.1 for iron valves.

2. Solder Joint: With sockets according to ASME B16.18.
3. Threaded: With threads according to ASME B1.20.1.

G. Valve Bypass and Drain Connections: MSS SP-45.

2.2 BRONZE BALL VALVES

A. Two-Piece, Full-Port, Bronze Ball Valves with Stainless-Steel Trim:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Cannon
    b. Conbraco Industries, Inc.; Apollo Valves.
    c. Crane Co.; Crane Valve Group; Crane Valves.
    d. Grinnell
    e. Hammond Valve.
    f. Kitz
    g. Milwaukee Valve Company.
    h. NIBCO INC.
    i. Rockwell
    j. Stockham
    k. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
2. Description:
    a. Standard: MSS SP-110.
    b. Stem: Stainless steel.
    c. Ball: Stainless steel, vented.
    d. Refer to schedules in Part 3 for specific application requirements.

B. Three-Piece, Full-Port, Bronze Ball Valves with Stainless-Steel Trim:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Cannon
    b. Conbraco Industries, Inc.; Apollo Valves.

c. Grinnell

d. Hammond Valve.

e. Milwaukee Valve Company.

f. NIBCO INC.

g. Rockwell

h. Stockham

2. Description:

a. Standard: MSS SP-110.

b. Stem: Stainless steel.

c. Ball: Stainless steel, vented.

d. Refer to schedules in Part 3 for specific application requirements.

2.3 STAINLESS STEEL BALL VALVES (CLEAN STEAM AND CONDENSATE ONLY)

A. One-Piece, Full-Port, Stainless Steel Ball Valves with Stainless-Steel Trim:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following: a. NIBCO INC.

b. Milwaukee Valve Company.

c. Cannon

d. Kitz

2. Description:

a. Standard: MSS SP-110.

b. Seats: PTFE.

c. Stem: Stainless steel.

d. Ball: Stainless steel, vented.

e. Port: Full.

f. Refer to schedules in Part 3 for specific application requirements.

2.4 IRON GENERAL SERVICE BUTTERFLY VALVES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. ABZ Valve and Controls; a division of ABZ Manufacturing, Inc.

2. Centerline
3. Conbraco Industries, Inc.; Apollo Valves.
4. Crane Co.; Crane Valve Group; Stockham Division.
5. DeZurik Water Controls.
6. Grinnell
7. Hammond Valve.
8. Keystone
9. Milwaukee Valve Company.
10. NIBCO INC.
11. Watts Regulator Co.; a division of Watts Water Technologies, Inc. B.

Description:

1. .Standard: MSS SP-67, Type I
2. Stem: One- or two-piece stainless steel.
3. Disc: Aluminum bronze.
4. Refer to schedules in Part 3 for specific application requirements.

2.5 CARBON STEEL HIGH-PERFORMANCE BUTTERFLY VALVES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. ABZ Valve and Controls; a division of ABZ Manufacturing, Inc.
2. Bray Controls; a division of Bray International.
3. DeZurik Water Controls.
4. Flowseal
5. Keystone
6. Posi-Seal B. Description:

1. Standard: MSS SP-68
2. Stem: Stainless steel; offset from seat plane.
3. Disc: 316 stainless steel.
4. Service: Bidirectional.
5. Refer to schedules in Part 3 for specific application requirements.

2.6 BRONZE SILENT CHECK VALVES (PUMP DISCHARGE)

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following :

1. Crane Co.; Crane Valve Group; Crane Valves.
2. Crane Co.; Crane Valve Group; Jenkins Valves.
3. Crane Co.; Crane Valve Group; Stockham Division.
4. Milwaukee Valve Company.
5. Mueller Steam Specialty; a division of SPX Corporation. B. Description:

1. Standard: MSS SP-80, Type 1.
2. Disc: BUNA/TFE.
3. Refer to schedules in Part 3 for specific application requirements.

2.7 IRON, GLOBE SILENT CHECK VALVES (PUMP DISCHARGE)

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Crane Co.; Crane Valve Group; Crane Valves.
2. Crane Co.; Crane Valve Group; Jenkins Valves.
3. Crane Co.; Crane Valve Group; Stockham Division.
4. Milwaukee Valve Company.
5. Mueller Steam Specialty; a division of SPX Corporation. B. Description:

1. Standard: MSS SP-125.
2. Disc: Bronze.
3. Refer to schedules in Part 3 for specific application requirements.

2.8 BRONZE SWING CHECK VALVES

A. Bronze Swing Check Valves with Nonmetallic Disc:

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

   a. Crane Co.; Crane Valve Group; Crane Valves.
   b. Crane Co.; Crane Valve Group; Jenkins Valves.

c. Crane Co.; Crane Valve Group; Stockham Division.

d. Hammond Valve.

e. Kitz Corporation.

f. Milwaukee Valve Company.

g. NIBCO INC.

h. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

a. Standard: MSS SP-80, Type 4.

b. Body Design: Horizontal flow.

c. Disc: PTFE unless indicated otherwise in table.

d. Refer to schedules in Part 3 for specific application requirements.

B. Bronze Swing Check Valves with Bronze Disc:

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

a. Crane Co.; Crane Valve Group; Crane Valves.

b. Crane Co.; Crane Valve Group; Jenkins Valves.

c. Crane Co.; Crane Valve Group; Stockham Division.

d. Kitz Corporation.

e. Milwaukee Valve Company.

f. NIBCO INC.

2. Description:

a. Standard: MSS SP-80, Type 3.

b. Body Design: Horizontal flow.

c. Refer to schedules in Part 3 for specific application requirements.

2.9 IRON SWING CHECK VALVES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Crane Co.; Crane Valve Group; Crane Valves.

2. Crane Co.; Crane Valve Group; Jenkins Valves.

3. Crane Co.; Crane Valve Group; Stockham Division.

4. Hammond Valve.
5. Kitz Corporation (Class 125).
6. Legend Valve (Class 125).
7. Milwaukee Valve Company.
8. NIBCO INC.
9. Powell Valves (Class 125). B. Description:

1. Standard: MSS SP-71, Type I.
2. Body Design: Clear or full waterway.
3. Gasket: Asbestos free.
4. Refer to schedules in Part 3 for specific application requirements.

2.10 BRONZE GATE VALVES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following :

1. Crane Co.; Crane Valve Group; Crane Valves.
2. Crane Co.; Crane Valve Group; Jenkins Valves.
3. Crane Co.; Crane Valve Group; Stockham Division.
4. Hammond Valve.
5. Milwaukee Valve Company.
6. NIBCO INC. B. Description:

1. Standard: MSS SP-80, Type 2.
2. Packing: Asbestos free.
3. Handwheel: Malleable iron or bronze.
4. Refer to schedules in Part 3 for specific application requirements.

2.11 IRON GATE VALVES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Crane Co.; Crane Valve Group; Crane Valves.
2. Crane Co.; Crane Valve Group; Jenkins Valves (Class 125).
3. Crane Co.; Crane Valve Group; Stockham Division.

4. Hammond Valve.
5. Milwaukee Valve Company.
6. NIBCO INC. B. Description:

1. Standard: MSS SP-70, Type I.
2. Disc: Solid wedge.
3. Packing and Gasket: Asbestos free.
4. Refer to schedules in Part 3 for specific application requirements.

2.12 BRONZE GLOBE VALVES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Crane Co.; Crane Valve Group; Crane Valves.
2. Crane Co.; Crane Valve Group; Stockham Division (Class 125).
3. Grinnell
4. Hammond Valve.
5. Milwaukee Valve Company.
6. NIBCO INC.
7. Walworth B. Description:

1. Standard: MSS SP-80, Type 1 (Class 125).
2. Standard: MSS SP-80, Type 2 (Class 150)
3. Packing: Asbestos free.
4. Handwheel: Malleable iron or bronze.
5. Refer to schedules in Part 3 for specific application requirements.

2.13 IRON GLOBE VALVES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Crane Co.; Crane Valve Group; Crane Valves.
2. Crane Co.; Crane Valve Group; Jenkins Valves.
3. Crane Co.; Crane Valve Group; Stockham Division.
4. Grinnell
5. Hammond Valve.
6. Milwaukee Valve Company.

7. NIBCO INC. (Class 125)
8. Walworth B. Description:

1. .Standard: MSS SP-85, Type I
2. Packing and Gasket: Asbestos free.
3. Refer to schedules in Part 3 for specific application requirements.

2.14 ECCENTRIC PLUG VALVES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. DeZurik Water Controls.
2. Mueller
3. Rockwell
4. Stockham
5. Walworth B. Description:

1. Standard: MSS SP-108.
2. Bearings: Oil-impregnated bronze or stainless steel.
3. Stem-Seal Packing: Asbestos free.
4. Plug, Resilient-Seating Material: Suitable for potable-water service unless otherwise indicated.
5. Refer to schedules in Part 3 for specific application requirements.

2.15 STRAINERS:

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Sarco
2. Mueller
3. Watts
4. Armstrong B. Description:

1. For water service, strainers shall be full size of entering pipe size and have a maximum clean pressure drop of one psi.
2. For steam and steam condensate strainers shall be full size of entering pipe size and have a maximum clean pressure drop of 1/4 psi.

3. Pump start up strainer screens shall be used for cleaning and removed afterwards.
4. Provide blow-off valve on each strainer.
    a. Provide bronze strainers with end cap with threaded connection for blow off valve.
    b. Provide iron valves with bolted cover with threaded connection for blow off valve.
5. For clean steam and clean steam condensate, provide stainless steel.
6. Refer to schedules in Part 3 for specific application requirements.

2.16 VACUUM BREAKERS:

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Stockham
2. Milwaukee
3. Watts B. Description:

1. Vacuum breaker shall be installed in the horizontal position, flow arrow pointed towards the coil and of same size as connected pipe.
2. Mount vacuum breaker above connected pipe and enter pipe tee via 90 degree ell-drop after vacuum breaker. Inlet to vacuum breaker shall be piped so that it does not allow discharge from a faulty vacuum breaker to spray on someone or electrical or wet- sensitive equipment. Piping shall turn towards pieces of equipment served.
3. Refer to schedules in Part 3 for specific application requirements.

2.17 CHAINWHEELS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    1. Babbitt Steam Specialty Co.
    2. Roto Hammer Industries.
    3. Trumbull Industries.
B. Description: Valve actuation assembly with sprocket rim, brackets, and chain.
    1. Brackets: Type, number, size, and fasteners required to mount actuator on valve.
    2. Attachment: For connection to ball, butterfly, gate and globe valve stems.
    3. Sprocket Rim with Chain Guides: Ductile iron, of type and size required for valve. Provide zinc coating.

4. Chain: Hot-dip, galvanized steel, of size required to fit sprocket rim. PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

C. Examine threads on valve and mating pipe for form and cleanliness.

D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

E. Do not attempt to repair defective valves; replace with new valves.

3.2 VALVE INSTALLATION

A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

B. Locate valves for easy access and provide separate support where necessary.

C. Install valves in horizontal piping with stem at or above center of pipe.

D. Install valves in position to allow full stem movement.

E. Install chain wheels on operators for ball, butterfly, gate and globe valves NPS 3 and larger and more than 84 inches above floor. Extend chains to 60 inches above finished floor.

F. Install check valves for proper direction of flow and as follows:

1. Swing Check Valves: In horizontal position with hinge pin level.
2. Silent Check Valves: In horizontal or vertical position, between flanges.

3.3 ADJUSTING

A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

3.4 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. Valves on steam, steam condensate, condenser water, chilled water, hot water and glycol services shall be as shown in the following tables. If valve applications are not indicated, use the following:

1. Shutoff Service: Ball, butterfly, or gate valves.
2. Butterfly Valve Dead-End Service: Single-flange (lug) type.
3. Throttling Service except Steam: Globe, ball, or butterfly valves.
4. Throttling Service, Steam: Globe valves.
5. Pump-Discharge Check Valves:
    a. NPS 2 and Smaller: Spring wafer check valve with bronze disc. .
    b. NPS 2-1/2 and Larger: Iron, center-guided, metal -seat check valves.

B. If valves with specified SWP classes or CWP ratings are not available, the same types of valves with higher SWP classes or CWP ratings may be substituted.

C. Select valves with end connections as indicated in the tables. For applications not listed in the tables select valves, except wafer types, with the following end connections:

1. For Copper Tubing, NPS 2 and Smaller: Threaded ends.
2. For Steel Piping, NPS 2 and Smaller: Threaded ends.
3. For Steel Piping, NPS 2-1/2 to NPS 4: Flanged ends.
4. For Steel Piping, NPS 5 and Larger: Flanged ends.

STEAM AND CONDENSATE SERVICE Maximum 90 psig Saturated Steam						
Specialty	Application	Type	Size (inches)	Body/Seat Body/Trim	Connection	Minimum Rating, 1, 2
Ball Valve	Not used					
Ball Valve	Clean Steam and Clean Condensate	One Piece	1/2 - 2	316 Stainless Steel	Threaded	150 psig
Gate Valve	Isolation	Union Bonnet	1/2 - 2	Bronze/Bronze Bronze/Bronze	Threaded	Class 125
		OS&Y	2-1/2 - 36	Iron/Bronze Iron/Iron	Flanged	Class 125
Globe Valve	Manual Steam Modulation Only and Automatic Control	Union Bonnet	1/2 - 2	Bronze/Stainless Bronze/Bronze	Threaded	125 psig SWP
		OS&Y	2-1/2 - 10	Iron/Bronze	Flanged	Class 125
Butterfly Valve	Not Used					
Plug Valve	Not Used					
Check Valve	Steam and Condensate Horizontal Flow	Non-Y-Type Swing Check Valve	1/2 - 2	Bronze/Teflon	Threaded (Use Dielectrics for Condensate)	125 psig SWP
			2-1/2 - 30	Iron/Iron	Flanged	125 SWP
Strainer	Control Valves and Flow Meters and Steam Traps	Y-Type	1/2 - 2	Bronze/Stainless (1/16 inch dia.)	Threaded	Class 125
			2-1/2 - 10	Iron/Stainless (3/64 inch dia.)	Flanged	Class 125
			12 - 24	Iron/Stainless (1/16 inch dia.)	Flanged	Class 125
Vacuum Breaker	Steam Coils and HX and Condensate Trap Legs	Non-Y-Type Swing Check Valve	1/2 - 2	Bronze/Teflon	Threaded (Use Dielectrics for Condensate)	Class 125
1. These are minimum ratings. For actual maximum allowable valve and strainer ratings, refer to "Pressure Temperature Ratings-Non Shock" tables. 2. SWP = Steam Working Pressure WOG = Water, Oil or Gas WSP = Working Steam Pressure Class = ANSI Standard						

STEAM AND CONDENSATE SERVICE Maximum 200 psig Saturated Steam						
Specialty	Application	Type	Size (inches)	Body/Seat Body/Trim	Connection	Minimum Rating[1], 2
Ball Valve	Not used					
Gate Valve	Isolation	Union Bonnet	1/2 - 2	Bronze/Bronze Bronze/Bronze	Threaded	Class 300

		OS&Y	2-1/2 - 36	Iron/Bronze Iron/Iron	Flanged	Class 250
Globe Valve	Manual Steam Modulation and Automatic Control	Union Bonnet	1/2 - 2	Bronze/Stainless Bronze/Bronze	Threaded	250 psig SWP
		OS&Y	2-1/2 - 10	Iron/Bronze	Flanged	Class 250
Butterfly Valve	Not Used					
Plug Valve	Not Used					
Check Valve	Steam and Condensate Horizontal Flow	Non-Y-Type Swing Check Valve	1/2 - 2	Bronze/Teflon	Threaded (Use Dielectrics for Condensate)	250 psig WSP
			2-1/2 - 30	Iron/Iron	Flanged	Class 250
Strainer	Control Valves and Flow Meters and Steam Traps	Y-Type	1/2 - 2	Bronze/Stainless (1/16 inch dia.)	Threaded	Class 250
			2-1/2 -10	Iron/Stainless (3/64 inch dia.)	Flanged	Class 250
			12 - 24	Iron/Stainless (1/16 inch dia.)	Flanged	Class 250
Vacuum Breaker	Steam Coils and HX and Condensate Trap Legs	Non-Y-Type Swing Check Valve	1/2 - 2	Bronze/Teflon	Threaded (Use Dielectrics for Condensate)	Class 250

1. These are minimum ratings. For actual maximum allowable valve and strainer ratings, refer to "Pressure Temperature Ratings-Non Shock" tables.
2. SWP = Steam Working Pressure WOG = Water, Oil or Gas WSP = Working Steam Pressure Class = ANSI Standard

GLYCOL, CHILLED AND CONDENSER WATER SERVICE
Maximum 150°F and 150 psig (1/2 inch - 12 inches), 125 psig (14 inches - 24 inches)

Specialty	Application	Type	Size (inches)	Body/Seat Body/Trim	Connection	Minimum Rating[1,2]
Ball Valve	Isolation (with locking handle) and Modulation	Full Port 3-pc.	1/2 - 2	Bronze/Teflon	Sweat[1]	400 psig WOG
		Full Port 2 pc.	1/2 - 2	Bronze/Teflon	Threaded	400 psig WOG
Gate Valve	Not Used					
Globe Valve	ATC Modulation	Control Valve	1/2 - 2	Bronze/Metal	Threaded	400 psig WOG
			2-1/2 - 6	Bronze/Metal	Flanged	400 psig WOG
Butterfly Valve	Isolation and Modulation	General Service	2-1/2 - 12	Ductile Iron/EPDM	Threaded Lug	175 psig CWP 150 psig bi- directional shutoff 150 psig dead end service

		General Service	14 - 24	Ductile Iron/EPDM	Threaded Lug	150 psig CWP 150 psig bi- directional shutoff 150 psig dead end service
Plug Valve	Manual Balancing	Non-lubricated	3 - 12	Steel/Iron	Flanged	Class 125
Check Valve	Pumps	Silent	1/2 - 2	Bronze/Bronze	Threaded	200 psig WOG
		Silent Globe	2-1/2 - 24	Iron/Bronze	Flanged	Class 125
	Piping	Y-Pattern Swing	1/2 - 2	Bronze/Bronze	Threaded	200 psig WOG
			2-1/2 - 24	Iron/Bronze	Flanged	Class 125
Strainer	Control Valves and Flow Meters	Y-Type	1/2 -2	Bronze/Stainless (1/16 inch dia.)	Threaded	200 psig WOG
			2-1/2 - 4	Iron/Stainless (1/16 inch dia.)	Flanged	Class 125
			5 - 24	Iron/Stainless (1/8 inch dia.)	Flanged	Class 125
	Pump Suction	In-Line Y-Type	1/2 - 2	Bronze/Stainless (1/16 inch dia.)	Threaded	200 psig WOG
			2-1/2 - 4	Iron/Stainless (3/16 inch dia.)[3]	Flanged	Class 125
			5 - 24	Iron/Stainless (1/4 inch dia.)[3]	Flanged	Class 125
		Angle Suction Diffuser End Suction Pumps	2 - 12	Iron/Stainless (3/16 inch dia.)[3] Start Up Strainer = 16 Mesh Bronze	Flanged	Class 125

1. These are minimum ratings for ASTM A126, Class B and ASTM B-61 and 62. For higher pressures and temperatures, adjust these values to include static head plus 1.1 times pressure relief valve setting plus pump shutoff head pressure. For actual maximum allowable valve and strainer ratings, refer to "Pressure-Temperature Ratings - Non Shock" tables and "Adjusted Pressure Ratings" for copper tube, soldered end valves [and strainers].
2. SWP=Steam Working Pressure CWP=Cold Water Working Pressure WSP=Working Steam Pressure WOG=Water, Oil or Gas Class=ANSI Standard
3. Use 1/8 inch dia for plate heat exchanger application.

GLYCOL, CHILLED AND CONDENSER WATER SERVICE Maximum 150□F and 275 psig (1/2 inch - 24 inches)						
Specialty	Application	Type	Size (inches)	Body/Seat Body/Trim	Connection	Minimum Rating[1,2]
Ball Valve	Isolation (with locking handle) and Modulation	Full Port 2 pc.	1/2 - 2	Bronze/Teflon	Threaded	600 psig WOG
Gate Valve	Not Used					
Globe Valve	ATC Modulation	Control Valve	1/2 - 2	Bronze/Metal	Threaded	600 psig WOG
			2-1/2 - 6	Bronze/Metal	Flanged	600 psig WOG

Butterfly Valve	Isolation and Modulation	High Performance	2-1/2 - 24	Carbon Steel/PTFE	Threaded Lug	285 psig CWP
Plug Valve	Manual Balancing	Non-lubricated	3 - 12	Steel/Iron	Flanged	Class 300
Check Valve	Pumps	Silent	1 - 2	Bronze/Bronze	Threaded	Class 300
		Silent Globe	2-1/2 - 24	Iron/Bronze	Flanged	Class 250
	Piping	Y-Pattern Swing	1/2 - 2	Bronze/Bronze	Threaded	Class 300
			2-1/2 - 24	Iron/Bronze	Flanged	Class 250
Strainer	Control Valves and Flow Meters	Y-Type	1/2 - 2	Bronze/Stainless (1/16 inch dia.)	Threaded	Class 250
			2-1/2 - 4	Iron/Stainless (1/16 inch dia.)	Flanged	Class 250
			5 - 24	Iron/Stainless (1/8 inch dia.)	Flanged	Class 250
	Pump Suction	In-Line Y-Type	1/2 - 2	Iron/Stainless (1/16 inch dia.)	Threaded	Class 250
			2-1/2 - 4	Iron/Stainless (3/16 inch dia.)[3]	Flanged	Class 250
			5 - 24	Iron/Stainless (1/4 inch dia.)[3]	Flanged	Class 250
		Angle Suction Diffuser End Suction Pumps	2 - 12	Iron/Stainless (3/16 inch dia.)[3] Start Up Strainer = 16 Mesh Bronze	Flanged	Class 250

1. These are minimum ratings. For higher pressures and temperatures, adjust these values to include static head plus 1.1 times pressure relief valve setting plus pump shutoff head pressure. For actual maximum allowable valve and strainer ratings, refer to "Pressure-Temperature Ratings - Non Shock" tables.
2. SWP=Steam Working Pressure CWP=Cold Water Working Pressure WSP=Working Steam Pressure WOG=Water, Oil or Gas Class=ANSI Standard
3. Use 1/8 inch dia for plate heat exchanger application.

GLYCOL, CHILLED AND CONDENSER WATER SERVICE
Maximum 150□F and 500 psig (½" - 24")/300 psig (14"-24")

Specialty	Application	Type	Size (inches)	Body/Seat Body/Trim	Connection	Minimum Rating[1,2]
Ball Valve	Isolation (with locking handle) and Modulation	Full Port 2 pc.	1/2 - 2	Bronze/Teflon	Threaded	600 psig WOG
Gate Valve	Not Used					
Globe Valve	ATC Modulation	Control Valve	1/2 - 2	Bronze/Metal	Threaded	600 psig WOG
			2-1/2 - 6	Bronze/Metal	Flanged	600 psig WOG
Butterfly Valve	Isolation and Modulation	High Performance	2-1/2 - 24	Carbon Steel/PTFE	Threaded Lug	740 psig CWP
Plug Valve	Manual Balancing	Non-lubricated	3 -12	Steel/Iron	Flanged	Class 300

Check Valve	Pumps	Silent	1 - 2	Bronze/Bronze	Threaded	Class 300
		Silent Globe	2-1/2 - 24	Iron/Bronze	Flanged	Class 250
	Piping	Y-Pattern Swing	1/2 - 2	Bronze/Bronze	Threaded	Class 300
			2-1/2 - 24	Iron/Bronze	Flanged	Class 250
Strainer	Control Valves and Flow Meters	Y-Type	1/2 - 2	Bronze/Stainless (1/16" dia.)	Threaded	Class 250
			2-1/2 - 4	Iron/Stainless (1/16" dia.)	Flanged	Class 250
			5 - 24	Iron/Stainless (1/8" dia.)	Flanged	Class 250
	Pump Suction	In-Line Y-Type	1/2 - 2	Iron/Stainless (1/16" dia.)	Threaded	Class 250
			2-1/2 - 4	Iron/Stainless (3/16" dia.)[3]	Flanged	Class 250
			5 - 24	Iron/Stainless (¼" dia.)[3]	Flanged	Class 250
		Angle Suction Diffuser End Suction Pumps	2 - 12	Iron/Stainless (3/16" dia.)[3] Start Up Strainer = 16 Mesh Bronze	Flanged	Class 250

1. These are minimum ratings. For higher pressures and temperatures, adjust these values to include static head plus 1.1 times pressure relief valve setting plus pump shutoff head pressure. For actual maximum allowable valve and strainer ratings, refer to "Pressure-Temperature Ratings - Non Shock" tables.
2. SWP=Steam Working Pressure CWP=Cold Water Working Pressure WSP=Working Steam Pressure WOG=Water, Oil or Gas Class=ANSI Standard
3. Use 1/8 inch dia for plate heat exchanger application.

GLYCOL AND HOT WATER SERVICE Maximum 250□F and 175 psig (½"-12")/125 psig (14"-24")						
Specialty	Application	Type	Size (inches)	Body/Seat, Body/Trim	Connection	Minimum Rating1,2
Ball Valve	Isolation (with locking handle) and Modulation	Full Port 3-pc.	1/2 - 2	Bronze/Teflon	Sweat[1]	400 psig WOG
		Full Port 2 pc.	1/2 - 2	Bronze/Teflon	Threaded	400 psig WOG
Gate Valve	Not Used					
Globe Valve	ATC Modulation	Control Valve	1/2 - 2	Bronze/Metal	Threaded	400 psig WOG
			2-1/2 - 6	Bronze/Metal	Flanged	400 psig WOG
Butterfly Valve	Isolation and Modulation	General Service	2-1/2 - 12	Ductile Iron/EPDM	Threaded Lug	200 psig CWP 200 psig bi-directional shutoff 200 psig dead end service

			14 - 24	Ductile Iron/EPDM	Threaded Lug	150 psig CWP 150 psig bi-directional shutoff 150 psig dead end service
Plug Valve	Manual Balancing	Non-lubricated	3 -12	Steel/Iron	Flanged	Class 125
Check Valve	Pumps	Silent	1/2 - 2	Bronze/Bronze	Threaded	200 psig WOG
		Silent Globe	2-1/2 - 24	Iron/Bronze	Flanged	Class 125
	Piping	Y-Pattern Swing	1/2 - 2	Bronze/Bronze	Threaded	200 psig WOG
			2-1/2 - 24	Iron/Bronze	Flanged	Class 125
Strainer	Control Valves and Flow Meters	Y-Type	1/2 - 2	Bronze/Stainless (1/16" dia.)	Threaded	200 psig WOG
			2-1/2 - 4	Iron/Stainless (1/16" dia.)	Flanged	Class 125
			5 - 24	Iron/Stainless (1/8" dia.)	Flanged	Class 125
	Pump Suction	In-Line Y-Type	1/2 - 2	Bronze/Stainless (1/16" dia.)	Threaded	200 psig WOG
			2-1/2 - 4	Iron/Stainless (3/16" dia.)[3]	Flanged	Class 125
			5 -24	Iron/Stainless (¼" dia.)[3]	Flanged	Class 125
		Angle Suction Diffuser End Suction Pumps	2 - 12	Iron/Stainless (3/16" dia.)[3] Start Up Strainer = 16 Mesh Bronze	Flanged	Class 125

1. These are minimum ratings for ASTM A126, Class B and ASTM B-61 and 62. For higher pressures and temperatures, adjust these values to include static head plus 1.1 times pressure relief valve setting plus pump shutoff head pressure. For actual maximum allowable valve and strainer ratings, refer to "Pressure-Temperature Ratings - Non Shock" tables and "Adjusted Pressure Ratings" for copper tube, soldered end valves [and strainers].
2. SWP=Steam Working Pressure CWP=Cold Water Working Pressure WSP=Working Steam Pressure WOG=Water, Oil or Gas Class=ANSI Standard
3. Use 1/8 inch dia for plate heat exchanger application.

GLYCOL AND HOT WATER SERVICE Maximum
225□F and 250 psig (½"-24")

Specialty	Application	Type	Size (inches)	Body/Seat, Body/Trim	Connection	Minimum Rating1,2
Ball Valve	Isolation (with locking handle) and Modulation	Full Port 3-pc.	1/2 - 2	Bronze/Teflon	Sweat[1]	400 psig WOG
		Full Port 2 pc.	1/2 - 2	Bronze/Teflon	Threaded	400 psig WOG
Gate Valve	Not Used					
Globe Valve	ATC Modulation	Control Valve	1/2 - 2	Bronze/Metal	Threaded	400 psig WOG
			2-1/2 - 6	Bronze/Metal	Flanged	600 psig WOG

Butterfly Valve	Isolation and Modulation	High Performance	2-1/2 - 24	Carbon Steel/PTFE	Threaded Lug	285 psig CWP
Plug Valve	Manual Balancing	Non-lubricated	3 - 12	Steel/Iron	Flanged	Class 250
Check Valve	Pumps	Silent	1 - 2	Bronze/Bronze	Threaded	Class 250
		Silent Globe	2-1/2 - 24	Iron/Bronze	Flanged	Class 250
	Piping	Y-Pattern Swing	1 -2	Bronze/Bronze	Threaded	Class 250
			2-1/2 - 24	Iron/Bronze	Flanged	Class 250
Strainer	Control Valves and Flow Meters	Y-Type	1/2 - 2	Bronze/Stainless (20 mesh)	Threaded	400 psi WOG
			2-1/2 - 4	Iron/Stainless (1/16" dia.)	Flanged	Class 250
			5 - 24	Iron/Stainless (1/8" dia.)	Flanged	Class 250
	Pump Suction	In-Line Y-Type	1/2 - 2	Bronze/Stainless (1/16" dia.)	Threaded	400 psig WOG
			2-1/2 - 4	Iron/Stainless (3/16" dia.)[3]	Flanged	Class 250
			5 - 24	Iron/Stainless (¼" dia.)[3]	Flanged	Class 250
		Angle Suction Diffuser End Suction Pumps	2 - 12	Iron/Stainless (3/16" dia.)[3] Start Up Strainer = 16 Mesh Bronze	Flanged	Class 250

1. These are minimum ratings for ASTM A126, Class B and ASTM B-61 and 62. For higher pressures and temperatures, adjust these values to include static head plus 1.1 times pressure relief valve setting plus pump shutoff head pressure. For actual maximum allowable valve and strainer ratings, refer to "Pressure-Temperature Ratings - Non Shock" tables and "Adjusted Pressure Ratings" for copper tube, soldered end valves [and strainers].
2. SWP=Steam Working Pressure CWP=Cold Water Working Pressure WSP=Working Steam Pressure WOG=Water, Oil or Gas Class=ANSI Standard
3. Use 1/8 inch dia for plate heat exchanger application.

HOT WATER SERVICE
Maximum 250□F and 400 psig (½"-12")/250 psig (14"-24")

Specialty	Application	Type	Size (inches)	Body/Seat, Body/Trim	Connection	Minimum Rating1,2
Ball Valve	Isolation (with locking handle) and Modulation	Full Port 3-pc.	1/2 - 2	Bronze/Teflon	Sweat[1]	Do not use
		Full Port 2 pc.	1/2 - 2	Bronze/Teflon	Threaded	600 psig WOG
Gate Valve	Not Used					
Globe Valve	ATC Modulation	Control Valve	1/2 = 2	Bronze/Metal	Threaded	600 psig WOG
			2-1/2 - 6	Bronze/Metal	Flanged	600 psig WOG
Butterfly Valve	Isolation and Modulation	High Performance	2-1/2 - 24	Carbon Steel/PTFE	Threaded Lug	740 psig CWP
Plug Valve	Manual Balancing	Non-lubricated	3 - 12	Steel/Iron	Flanged	Class 250

Check Valve	Pumps	Silent	1 - 2	Bronze/Bronze	Threaded	Class 250
		Silent Globe	2-1/2 - 24	Iron/Bronze	Flanged	Class 250
	Piping	Y-Pattern Swing	1 - 2	Bronze/Bronze	Threaded	Class 250
			2-1/2 - 24	Iron/Bronze	Flanged	Class 250
Strainer	Control Valves and Flow Meters	Y-Type	1/2 - 2	Bronze/Stainless (20 mesh)	Threaded	600 psig WOG
			2-1/2 - 4	Iron/Stainless (1/16" dia.)	Flanged	Class 250
			5 - 24	Iron/Stainless (1/8" dia.)	Flanged	Class 250
	Pump Suction	In-Line Y-Type	1/2 - 2	Bronze/Stainless (1/16" dia.)	Threaded	600 psig WOG
			2-1/2 - 4	Iron/Stainless (3/16" dia.)[3]	Flanged	Class 250
			5 - 24	Iron/Stainless (¼" dia.)[3]	Flanged	Class 250
		Angle Suction Diffuser End Suction Pumps	2 -12	Iron/Stainless (3/16" dia.)[3] Start Up Strainer = 16 Mesh Bronze	Flanged	Class 250

1. These are minimum ratings for ASTM A126, Class B and ASTM B-61 and 62. For higher pressures and temperatures, adjust these values to include static head plus 1.1 times pressure relief valve setting plus pump shutoff head pressure. For actual maximum allowable valve and strainer ratings, refer to "Pressure-Temperature Ratings - Non Shock" tables and "Adjusted Pressure Ratings" for copper tube, soldered end valves [and strainers].
2. SWP=Steam Working Pressure CWP=Cold Water Working Pressure WSP=Working Steam Pressure WOG=Water, Oil or Gas Class=ANSI Standard
3. Use 1/8 inch dia for plate heat exchanger application.

END OF SECTION

SECTION 230529
HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Metal pipe hangers and supports.
2. Trapeze pipe hangers.
3. Metal framing systems.
4. Thermal-hanger shield inserts.
5. Fastener systems.
6. Pipe stands.
7. Equipment supports. B. Related Requirements:

1. Section 055000 "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
2. Section 230516 "Expansion Fittings and Loops for HVAC Piping" for pipe guides and anchors.
3. Section 230548 "Vibration and Seismic Controls for HVAC",
   Section 230548.13 "Vibration Controls for HVAC" for vibration isolation devices.
4. Section 233113 "Metal Ducts" for duct hangers and supports.

1.3 DEFINITIONS

A. MSS: Manufacturers Standardization Society for the Valve and Fittings Industry Inc.

B. Terminology: As defined in MSS SP-90, "Guidelines on Terminology for Pipe Hangers and Supports."

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.
B. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following; include Product Data for components:

1. Trapeze pipe hangers.
2. Metal framing systems.
3. Fiberglass strut systems.
4. Pipe stands.
5. Equipment supports.

C. Delegated-Design Submittal: For trapeze hangers indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of trapeze hangers.
2. Include design calculations for designing trapeze hangers.

1.5 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Product Data: For the following:
1. Steel pipe hangers and supports.
2. Thermal-hanger shield inserts.

C. Shop Drawings: Show fabrication and installation details and include calculations for the following:
1. Trapeze pipe hangers. Include Product Data for components.
2. Metal framing systems. Include Product Data for components.
3. Pipe stands. Include Product Data for components.
4. Equipment supports.

1.6 QUALITY ASSURANCE

A. Structural-Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code, Section IX.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design trapeze pipe hangers and equipment supports.

B. Structural Performance: Hangers and supports for HVAC piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.

1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
3. Design seismic-restraint hangers and supports for piping and equipment and obtain approval from authorities having jurisdiction.

2.2 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.

2.3 METAL PIPE HANGERS AND SUPPORTS

A. Description: MSS SP-58, Types 1 through 58, factory-fabricated components. Refer to Part 3 "Hanger and Support Applications" Article for where to use specific hanger and support types.

B. Manufacturers:

1. B-Line Systems, Inc.; a division of Cooper Industries.
2. Carpenter & Paterson, Inc.
3. Empire Industries, Inc.
4. ERICO/Michigan Hanger Co.
5. Globe Pipe Hanger Products, Inc.
6. Grinnell Corp.
7. National Pipe Hanger Corporation.
8. PHD Manufacturing, Inc.
9. PHS Industries, Inc.
10. Piping Technology & Products, Inc.

C. Carbon-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Galvanized Metallic Coatings: Pregalvanized, hot-dip galvanized, or electrogalvanized.
3. Nonmetallic Coatings: Plastic coated, or epoxy powder-coated.
4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.

5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel or stainless steel.

D. Stainless-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
3. Hanger Rods: Continuous-thread rod, nuts, and washer made of stainless steel.

E. Copper Pipe and Tube Hangers:

1. Description: MSS SP-58, Types 1 through 58, copper-plated steel, factoryfabricated components.
2. Hanger Rods: Continuous-thread rod, nuts, and washer made of copperplated steel or stainless steel.

2.4 TRAPEZE PIPE HANGERS

A. Description: MSS SP-58, Type 59, shop- or field-fabricated pipe-support assembly made from structural carbon-steel shapes with MSS SP-58 carbon-steel hanger rods, nuts, saddles, and U-bolts.

2.5 METAL FRAMING SYSTEMS

A. Description: MFMA-3, shop- or field-fabricated pipe-support assembly made of steel channels and other components.

B. Manufacturers:

1. B-Line Systems, Inc.; a division of Cooper Industries.
2. ERICO/Michigan Hanger Co.; ERISTRUT Div.
3. GS Metals Corp.
4. Power-Strut Div.; Tyco International, Ltd.
5. Thomas & Betts Corporation.
6. Unistrut Corp.; Tyco International, Ltd.

C. MFMA Manufacturer Metal Framing Systems:

1. Description: Shop- or field-fabricated, pipe-support assembly made of steel channels, accessories, fittings, and other components for supporting multiple parallel pipes.
2. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
3. Channels: Continuous slotted carbon-steel, stainless-steel, Type 304, or stainless-steel, Type 316 or extruded-aluminum channel with inturned lips.
4. Channel Width: Selected for applicable load criteria.
5. Channel Nuts: Formed or stamped nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.

6. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel or stainless steel.
7. Metallic Coating: No coating, Plain, Pregalvanized G90, Electroplated zinc, Hot-dip galvanized.
8. Paint Coating: Green epoxy, acrylic, or urethane.
9. Plastic Coating: PVC.

D. Non-MFMA Manufacturer Metal Framing Systems:
1. Description: Shop- or field-fabricated, pipe-support assembly made of steel channels, accessories, fittings, and other components for supporting multiple parallel pipes.
2. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
3. Channels: Continuous slotted carbon-steel or stainless-steel channel with inturned lips.
4. Channel Width: Select for applicable load criteria.
5. Channel Nuts: Formed or stamped nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
6. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel or stainless steel.
7. Metallic Coating: No coating, Plain, Pregalvanized, Hot-dip galvanized.
8. Paint Coating: Green epoxy, acrylic, or urethane.
9. Plastic Coating: PVC.

2.6 THERMAL-HANGER SHIELD INSERTS

A. Description: 100-psig- minimum, compressive-strength insulation insert encased in sheet metal shield. Insert shall be capable of supporting weight of pipe, insulations and fluid without crushing.

B. Manufacturers:
1. Carpenter & Paterson, Inc.
2. ERICO/Michigan Hanger Co.
3. PHS Industries, Inc.
4. Pipe Shields, Inc.
5. Rilco Manufacturing Company, Inc.
6. Value Engineered Products, Inc.

C. Insulation-Insert Material for Cold Piping: [ASTM C 552, Type II cellular glass with 100-psi] [or] [ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psi] minimum compressive strength and vapor barrier.

D. Insulation-Insert Material for Hot Piping: [Water-repellent-treated, ASTM C 533, Type I calcium silicate with 100-psi] [ASTM C 552, Type II cellular glass with 100psi] [or] [ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psi minimum compressive strength.

E. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.

F. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.

G. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.7 FASTENER SYSTEMS

A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

B. Mechanical-Expansion Anchors: Insert-wedge-type zinc-coated or stainless steel, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
1. Indoor Applications: Zinc-coated or stainless-steel.
2. Outdoor Applications: Stainless steel.

C. Manufacturers:
1. B-Line Systems, Inc.; a division of Cooper Industries.
2. Empire Industries, Inc.
3. Hilti, Inc.
4. ITW Ramset/Red Head.
5. MKT Fastening, LLC.
6. Powers Fasteners.

2.8 PIPE STANDS

A. General Requirements for Pipe Stands: Shop- or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.

B. Pipe Stands, General: Shop or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.

C. Compact Pipe Stand: One-piece plastic unit with integral-rod-roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.

D. Available Manufacturers:
1. ERICO/Michigan Hanger Co.
2. MIRO Industries. E. Compact Pipe Stand:

1. Description: Single base unit with integral-rod roller, pipe clamps, or Vshaped cradle to support pipe, for roof installation without membrane penetration.
2. Base: Single, vulcanized rubber, molded polypropylene, or polycarbonate.

3. Hardware: Galvanized steel or polycarbonate.
4. Accessories: Protection pads.

F. Low-Profile, Single Base, Single-Pipe Stand:

1. Description: Single base with vertical and horizontal members, and pipe support, for roof installation without membrane protection.
2. Base: Single, vulcanized rubber, molded polypropylene, or polycarbonate.
3. Available Manufacturers:
   a. MIRO Industries.

4. Vertical Members: Two, [galvanized] [stainless]-steel, continuous-thread 1/2inch rods.
5. Horizontal Member: Adjustable horizontal, [galvanized] [stainless]-steel pipe support channels.
6. Pipe Supports: [Roller] [Strut clamps] [Clevis hanger] [Swivel hanger].
7. Hardware: [Galvanized] [Stainless] steel.
8. Accessories: Protection pads.
9. Height: 12 inches above roof.

G. High-Profile, Single Base, Single-Pipe Stand:

1. Description: Single base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
2. Base: Single vulcanized rubber or molded polypropylene.
3. Available Manufacturers:
   a. ERICO/Michigan Hanger Co.
   b. MIRO Industries.
   c. Portable Pipe Hangers

4. Vertical Members: Two, galvanized or stainless-steel, continuous-thread 1/2inch rods.
5. Horizontal Member: One, adjustable height, galvanized- or stainless-steel pipe support slotted channel or plate.
6. Pipe Supports: Roller or Clevis hanger or Swivel hanger.
7. Hardware: Galvanized or Stainless steel.
8. Accessories: Protection pads, 1/2-inch continuous-thread galvanized-steel rod, 1/2-inch continuous-thread stainless-steel rod.
9. Height: 36 inches above roof. H. High-Profile, Multiple-Pipe Stand:

1. Description: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.
2. Bases: Two or more; vulcanized rubber or molded polypropylene.
3. Available Manufacturers:
   a. Portable Pipe Hangers.

4. Vertical Members: Two or more, galvanized or stainless-steel channels.
5. Horizontal Members: One or more, adjustable height, galvanized or stainlesssteel pipe support.

6. Pipe Supports: Roller, Strut clamps, Clevis hanger.
7. Hardware: Galvanized or Stainless steel.
8. Accessories: Protection pads, 1/2-inch continuous-thread rod.
9. Height: 36 inches above roof.

I. Curb-Mounted-Type Pipe Stands: Shop- or field-fabricated pipe supports made from structural-steel shapes, continuous-thread rods, and rollers, for mounting on permanent stationary roof curb.

2.9 EQUIPMENT SUPPORTS

A. Description: Welded, shop- or field-fabricated equipment support made from structural carbon-steel shapes.

2.10 MATERIALS

A. Aluminum: ASTM B 221 (ASTM B 221M).

B. Carbon Steel: ASTM A 1011/A 1011M.

C. Structural Steel: ASTM A 36/A 36M, carbon-steel plates, shapes, and bars; galvanized.

D. Stainless Steel: ASTM A 240/A 240M.

E. Threaded Rods: Continuously threaded. Zinc-plated or galvanized steel for indoor applications and stainless steel for outdoor applications. Mating nuts and washers of similar materials as rods.

F. Grout: ASTM C 1107/C 1107M, factory-mixed and -packaged, dry, hydrauliccement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.

1. Properties: Nonstaining, noncorrosive, and nongaseous.
2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping materials and installation for penetrations through fire-rated walls, ceilings, and assemblies.

B. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus **200 lb**.

3.2 HANGER AND SUPPORT INSTALLATION

A. Metal Pipe-Hanger Installation: Comply with MSS SP-58. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.

B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-58. Arrange for grouping of parallel runs of horizontal piping, and support together on fieldfabricated trapeze pipe hangers.

1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.
2. Field fabricate from ASTM A 36/A 36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.

C. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled strut systems.

D. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.

E. Fastener System Installation:

1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches (100 mm) thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

F. Pipe Stand Installation:

1. Pipe Stand Types except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
2. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. See Section 077200 "Roof Accessories" for curbs.

G. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.

H. Equipment Support Installation: Fabricate from welded-structural-steel shapes.

I. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

J. Install lateral bracing with pipe hangers and supports to prevent swaying.

K. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

L. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

M. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.

N. Insulated Piping:

1. Attach clamps and spacers to piping.

   a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
   b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
   c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.

2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.

   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.

   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

4. Shield Dimensions for Pipe: Not less than the following:

   a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
   b. NPS 4: 12 inches long and 0.06 inch thick.
   c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
   d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.

e. NPS 16 to NPS 24: 24 inches long and 0.105 inch thick.

5. Pipes NPS 8 and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.3 EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.

B. Grouting: Place grout under supports for equipment and make bearing surface smooth.

C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.4 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.

B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.5 ADJUSTING

A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

3.6 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.

B. Touchup: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Division 09 painting Sections.

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780/A 780M.

3.7 HANGER AND SUPPORT SCHEDULE

A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.

B. Comply with MSS SP-58 for pipe-hanger selections and applications that are not specified in piping system Sections.

C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.

D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

E. Use carbon-steel pipe hangers and supports, metal trapeze pipe hangers and metal framing systems and attachments for general service applications.

F. Use stainless-steel pipe hangers, fiberglass pipe hangers and fiberglass strut systems and stainless-steel or corrosion-resistant attachments for hostile environment applications.

G. Use copper-plated pipe hangers and copper or stainless-steel attachments for copper piping and tubing.

H. Use padded hangers for piping that is subject to scratching.

I. Use thermal-hanger shield inserts for insulated piping and tubing.

J. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30.

2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 deg F, pipes NPS 4 to NPS 24, requiring up to 4 inches of insulation.
3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36, requiring clamp flexibility and up to 4 inches of insulation.
4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 if little or no insulation is required.
5. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated, stationary pipes NPS 3/4 to NPS 8.
7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
10. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 8.
11. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3.
12. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 3.
13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
14. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbonsteel plate.
15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbonsteel plate, and with U-bolt to retain pipe.
16. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 if vertical adjustment is required, with steelpipe base stanchion support and cast-iron floor flange.
17. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30), from two rods if longitudinal movement caused by expansion and contraction might occur.
18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 24, from single rod if horizontal movement caused by expansion and contraction might occur.
19. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is unnecessary.
20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes NPS 2 to NPS 24 if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is unnecessary.

21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 30 if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

K. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24.
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 if longer ends are required for riser clamps.

L. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.

M. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.
7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:

a. Light (MSS Type 31): 750 lb.
b. Medium (MSS Type 32): 1500 lb.
c. Heavy (MSS Type 33): 3000 lb.

13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

N. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.

O. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41, roll hanger with springs.
4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from hanger.
6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.
7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from trapeze support.
8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and loadadjustment capability. These supports include the following types:

a. Horizontal (MSS Type 54): Mounted horizontally.
b. Vertical (MSS Type 55): Mounted vertically.
c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.

P. Comply with MSS SP-58 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.

Q. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.

R. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.

END OF SECTION

SECTION 230533
HEAT TRACING FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes heat tracing for HVAC piping with the following electric heating cables:

1. Plastic insulated, series resistance.
2. Self-regulating, parallel resistance. B. Related

Requirements:

1. Section 210533 "Heat Tracing for Fire-Suppression Piping."
2. Section 220533 "Heat Tracing for Plumbing Piping."

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, and furnished specialties and accessories.
2. Schedule heating capacity, length of cable, spacing, and electrical power requirement for each electric heating cable required. B. Shop Drawings: For electric heating cable.

1. Include plans, elevations, sections, and attachment details.
2. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Sample Warranty: For special warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For electric heating cables to include in operation and maintenance manuals.

1.6 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace electric heating cable that fails in materials or workmanship within specified warranty period. 1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PLASTIC-INSULATED, SERIES-RESISTANCE HEATING CABLES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Delta-Therm Corporation.
2. Dekoron
3. Easy Heat; a division of EGS Electrical Group LLC.
4. Orbit Manufacturing.
5. Pyrotenax; a brand of Tyco Thermal Controls LLC.
6. Raychem; a brand of Tyco Thermal Controls LLC.
7. Watts Radiant, Inc.; a subsidiary of Watts Water Technologies, Inc. B.

Comply with IEEE 515.1.

C. Heating Element: Single- or dual-stranded resistor wire. Terminate with waterproof, factory-assembled, nonheating leads with connectors at both ends.

D. Electrical Insulating Jacket: Minimum 4.0-mil Kapton with silicone, Tefzel, or polyolefin.

E. Cable Cover: Aluminum braid and silicone or Hylar outer jacket.

F. Maximum Operating Temperature (Power On): 150 deg F.

G. Maximum Exposure Temperature (Power Off): 185 deg F.

H. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

I. Capacities and Characteristics:

1. Maximum Heat Output: 6 W/ft. maximum.
2. Piping Diameter: refer to floor plans.

3. Number of Parallel Cables: 2.
4. Spiral Wrap Pitch: 6 inches.
5. Electrical Characteristics for Single-Circuit Connection:

    a. Volts: 120
    b. Phase: 1
    c. Hertz: 60
    d. Full-Load Amperes: 15A.
    e. Minimum Circuit Ampacity: 10A.
    f. Maximum Overcurrent Protection: 20A.

2.2 SELF-REGULATING, PARALLEL-RESISTANCE HEATING CABLES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Delta-Therm Corporation.
2. BriskHeat.
3. Chromalox.
4. Easy Heat; a division of EGS Electrical Group LLC.
5. Pyrotenax; a brand of Tyco Thermal Controls LLC.
6. Raychem; a brand of Tyco Thermal Controls LLC.
7. Thermon Americas Inc.
8. Trasor Corp.

B. Comply with IEEE 515.1.

C. Heating Element: Pair of parallel No. 16 AWG, tinned, stranded copper bus wires embedded in crosslinked conductive polymer core, which varies heat output in response to temperature along its length. Terminate with waterproof, factoryassembled, nonheating leads with connectors at one end, and seal the opposite end watertight. Cable shall be capable of crossing over itself once without overheating. D. Electrical Insulating Jacket: Flame-retardant polyolefin.

E. Cable Cover: Tinned-copper and polyolefin outer jacket with ultraviolet inhibitor.

F. Maximum Operating Temperature (Power On): 150 deg F.

G. Maximum Exposure Temperature (Power Off): 185 deg F.

H. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

I. Capacities and Characteristics:

1. Maximum Heat Output: 5 W/ft.
2. Piping Diameter: refer to floor plans.
3. Number of Parallel Cables: 2.

4. Spiral Wrap Pitch: 6 inches.
5. Electrical Characteristics for Single-Circuit Connection:
    a. Volts: 120
    b. Phase: 1
    c. Hertz: 60
    d. Full-Load Amperes: 15A.
    e. Minimum Circuit Ampacity: 10A.
    f. Maximum Overcurrent Protection: 20A.

2.3 CONTROLS

A. Remote bulb unit with adjustable temperature range from 30 to 50 deg F.

B. Snap action; open-on-rise, single-pole switch with minimum current rating adequate for connected cable.

C. Remote bulb on capillary, resistance temperature device, or thermistor for directly sensing pipe-wall temperature.

D. Corrosion-resistant, waterproof control enclosure.

2.4 ACCESSORIES

A. Cable Installation Accessories: Fiberglass tape, heat-conductive putty, cable ties, silicone end seals and splice kits, and installation clips all furnished by manufacturer, or as recommended in writing by manufacturer.

B. Warning Labels: Refer to Section 230553 "Identification for HVAC Piping and Equipment."

C. Warning Tape: Continuously printed "Electrical Tracing"; vinyl, at least 3 mils thick, and with pressure-sensitive, permanent, waterproof, self-adhesive back.

    1. Width for Markers on Pipes with OD, Including Insulation, and Less Than 6 Inches: 3/4 inch minimum.
    2. Width for Markers on Pipes with OD, Including Insulation, 6 Inches or Larger: 1-1/2 inches minimum.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine surfaces and substrates to receive electric heating cables for compliance with requirements for installation tolerances and other conditions affecting performance.

1. Ensure surfaces and pipes in contact with electric heating cables are free of burrs and sharp protrusions.

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

3.2 INSTALLATION

A. Install electric heating cable across expansion joints according to manufacturer's written instructions; use slack cable to allow movement without damage to cable.

B. Install electric heating cables after piping has been tested and before insulation is installed.

C. Install electric heating cables according to IEEE 515.1.

D. Install insulation over piping with electric cables according to Section 230719 "HVAC Piping Insulation."

E. Install warning tape on piping insulation where piping is equipped with electric heating cables.

F. Set field-adjustable switches and circuit-breaker trip ranges.

3.3 CONNECTIONS

A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform the following tests and inspections with the assistance of a factoryauthorized service representative:

1. Perform tests after cable installation but before application of coverings such as insulation, wall or ceiling construction, or concrete.
2. Test cables for electrical continuity and insulation integrity before energizing.
3. Test cables to verify rating and power input. Energize and measure voltage and current simultaneously.

D. Repeat tests for continuity, insulation resistance, and input power after applying thermal insulation on pipe-mounted cables.

E. Cables will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports.

3.5 PROTECTION

A. Protect installed heating cables, including nonheating leads, from damage during construction.

B. Remove and replace damaged heat-tracing cables.

END OF SECTION

SECTION 230548
VIBRATION AND SEISMIC CONTROLS FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. Certain requirements common to all the mechanical and electrical trades (Fire Suppression, Plumbing, HVAC, Electrical, and Tele/Data) are specified in Division 20. To avoid repetition, they are not repeated in each relevant Section. These requirements are applicable to the work of this Division, and are hereby incorporated by reference.

1.2 SUMMARY

A. Section Includes:

1. Elastomeric isolation pads.
2. Elastomeric isolation mounts.
3. Restrained elastomeric isolation mounts.
4. Open-spring isolators.
5. Housed-spring isolators.
6. Restrained-spring isolators.
7. Housed-restrained-spring isolators.
8. Pipe-riser resilient supports.
9. Resilient pipe guides.
10. Air-spring isolators.
11. Restrained-air-spring isolators.
12. Elastomeric hangers.
13. Spring hangers.
14. Snubbers.
15. Restraint channel bracings.
16. Restraint cables.
17. Seismic-restraint accessories.
18. Mechanical anchor bolts.
19. Adhesive anchor bolts.
20. Restrained isolation roof-curb rails. B. Related Requirements:

1. Section 210548 "Vibration and Seismic Controls for Fire Suppression" for devices for fire-suppression equipment and systems.
2. Section 220548 "Vibration and Seismic Controls for Plumbing" for devices for plumbing equipment and systems.

1.3 DEFINITIONS

A. IBC: International Building Code.

B. ICC-ES: ICC-Evaluation Service.

C. OSHPD: Office of Statewide Health Planning & Development (for the State of California).

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of vibration isolation device and seismic-restraint component required.

    a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an evaluation service member of ICC-ES, an agency acceptable to authorities having jurisdiction.
    b. Annotate to indicate application of each product submitted and compliance with requirements.

3. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.

B. Shop Drawings:

1. Detail fabrication and assembly of equipment bases. Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

C. Delegated-Design Submittal: For each vibration isolation and seismic-restraint device.

1. Include design calculations and details for selecting vibration isolators, seismic restraints, and vibration isolation bases complying with performance requirements, design criteria, and analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
2. Design Calculations: Calculate static and dynamic loading due to equipment weight, operation, and seismic and wind forces required to select vibration isolators and seismic and wind restraints and for designing vibration isolation bases.

a. Coordinate design calculations with wind load calculations required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.

3. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, spring deflection changes, and seismic loads. Include certification that riser system was examined for excessive stress and that none exists.
4. Seismic **- and Wind**-Restraint Details:

   a. Design Analysis: To support selection and arrangement of seismic **and wind** restraints. Include calculations of combined tensile and shear loads.
   b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacing. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
   c. Coordinate seismic-restraint and vibration isolation details with windrestraint details required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.
   d. Preapproval and Evaluation Documentation: By an evaluation service member of ICC-ES, OSHPD, and an agency acceptable to authorities having jurisdiction], showing maximum ratings of restraint items and the basis for approval (tests or calculations).

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show coordination of vibration isolation device installation and seismic bracing for HVAC piping and equipment with other systems and equipment in the vicinity, including other supports and restraints, if any.

B. Qualification Data: For professional engineer and testing agency.

C. Welding certificates.

D. Air-Mounting System Performance Certification: Include natural frequency, load, and damping test data, performed by an independent agency. E. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air-spring mounts and restrained-air-spring mounts to include in operation and maintenance manuals.

1.7 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7 and that is acceptable to authorities having jurisdiction.

B. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.

C. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

D. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are unavailable, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Wind-Restraint Loading:

1. Basic Wind Speed: 100 mph.
2. Building Classification Category: IV.
3. Minimum 10 lb/sq. ft. multiplied by maximum area of HVAC component

projected on vertical plane normal to wind direction, and 45 degrees either side of normal.

B. Seismic-Restraint Loading:

1. Site Class as Defined in the IBC: **C or D**.
2. Assigned Seismic Use Group or Building Category as Defined in the IBC: IV.

    a. Component Importance Factor: 1.5.
    b. Component Response Modification Factor: 1.5.
    c. Component Amplification Factor: 2.5.

3. Design Spectral Response Acceleration at Short Periods (0.2 Second): 0.367 g.
4. Design Spectral Response Acceleration at 1.0-Second Period: 0.113 g.
5. Rated strengths, features, and applications shall be as defined in reports by an evaluation service member of ICC-ES and an agency acceptable to authorities having jurisdiction.

a. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they are subjected.

2.2 ELASTOMERIC ISOLATION PADS

A. Elastomeric Isolation Pads:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following :
   a. Ace Mountings Co., Inc.
   b. California Dynamics Corporation.
   c. Isolation Technology, Inc.
   d. Kinetics Noise Control, Inc.
   e. Mason Industries, Inc.
   f. Vibration Eliminator Co., Inc.
   g. Vibration Isolation.
   h. Vibration Mountings & Controls, Inc.

2. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area.
3. Size: Factory or field cut to match requirements of supported equipment.
4. Pad Material: Oil and water resistant with elastomeric properties.
5. Surface Pattern: Smooth, Ribbed, Waffle pattern.
6. Infused nonwoven cotton or synthetic fibers.
7. Load-bearing metal plates adhered to pads.
8. Sandwich-Core Material: Resilient, and elastomeric.

   a. Surface Pattern: Smooth, Ribbed, Waffle pattern.
   b. Infused nonwoven cotton or synthetic fibers.

2.3 ELASTOMERIC ISOLATION MOUNTS

A. Double-Deflection, Elastomeric Isolation Mounts:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following :
   a. Ace Mountings Co., Inc.
   b. California Dynamics Corporation.
   c. Isolation Technology, Inc.
   d. Kinetics Noise Control, Inc.
   e. Mason Industries, Inc.
   f. Vibration Eliminator Co., Inc.
   g. Vibration Isolation.
   h. Vibration Mountings & Controls, Inc.

2. Mounting Plates:
   a. Top Plate: Encapsulated steel load transfer top plates, factory drilled and threaded with threaded studs or bolts.
   b. Baseplate: Encapsulated steel bottom plates with holes provided for anchoring to support structure.

3. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.4 RESTRAINED ELASTOMERIC ISOLATION MOUNTS

A. Restrained Elastomeric Isolation Mounts:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following :
   a. Ace Mountings Co., Inc.
   b. California Dynamics Corporation.
   c. Isolation Technology, Inc.
   d. Kinetics Noise Control, Inc.
   e. Mason Industries, Inc.
   f. Vibration Eliminator Co., Inc.
   g. Vibration Isolation.
   h. Vibration Mountings & Controls, Inc.

2. Description: All-directional isolator with seismic restraints containing two separate and opposing elastomeric elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.

   a. Housing: Cast-ductile iron or welded steel.
   b. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.5 OPEN-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following :
   a. Ace Mountings Co., Inc.
   b. California Dynamics Corporation.
   c. Isolation Technology, Inc.
   d. Kinetics Noise Control, Inc.
   e. Mason Industries, Inc.
   f. Vibration Eliminator Co., Inc.
   g. Vibration Isolation.
   Vibration Mountings & Controls, Inc.

2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Baseplates: Factory-drilled steel plate for bolting to structure with an elastomeric isolator pad attached to the underside. Baseplates shall limit floor load to 500 psig.
7. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

2.6 HOUSED-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators in Two-Part Telescoping Housing:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following :
   a. Ace Mountings Co., Inc.
   b. California Dynamics Corporation.
   c. Isolation Technology, Inc.
   d. Kinetics Noise Control, Inc.
   e. Mason Industries, Inc.
   f. Vibration Eliminator Co., Inc.
   g. Vibration Isolation.
   h. Vibration Mountings & Controls, Inc.

2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators.

   a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig.
   b. Top housing with attachment and leveling bolt, threaded mounting holes and internal leveling device, or elastomeric pad.

2.7 RESTRAINED-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators with Vertical-Limit Stop Restraint:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following :
   a. Ace Mountings Co., Inc.

b. California Dynamics Corporation.
c. Isolation Technology, Inc.
d. Kinetics Noise Control, Inc.
e. Mason Industries, Inc.
f. Vibration Eliminator Co., Inc.
g. Vibration Isolation.
h. Vibration Mountings & Controls, Inc.

2. Housing: Steel housing with vertical-limit stops to prevent spring extension due to weight being removed.

   a. Base with holes for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig.
   b. Top plate with threaded mounting holes or elastomeric pad.
   c. Internal leveling bolt that acts as blocking during installation.

3. Restraint: Limit stop as required for equipment and authorities having jurisdiction.
4. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
5. Minimum Additional Travel: 50 percent of the required deflection at rated load.
6. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
7. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.8 HOUSED-RESTRAINED-SPRING ISOLATORS

A. Freestanding, Steel, Open-Spring Isolators with Vertical-Limit Stop Restraint in TwoPart Telescoping Housing:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following :
   a. Ace Mountings Co., Inc.
   b. California Dynamics Corporation.
   c. Isolation Technology, Inc.
   d. Kinetics Noise Control, Inc.
   e. Mason Industries, Inc.
   f. Vibration Eliminator Co., Inc.
   g. Vibration Isolation.
   h. Vibration Mountings & Controls, Inc.

2. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators. Housings are equipped with adjustable or non-adjustable snubbers to limit vertical movement.

   a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig.

b. Threaded top housing with adjustment bolt and cap screw to fasten and level equipment.

3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.9 PIPE-RISER RESILIENT SUPPORT

A. Description: All-directional, acoustical pipe anchor consisting of two steel tubes separated by a minimum 1/2-inch- thick neoprene.

1. Vertical-Limit Stops: Steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions.
2. Maximum Load Per Support: 500 psig on isolation material providing equal isolation in all directions.

2.10 RESILIENT PIPE GUIDES

A. Description: Telescopic arrangement of two steel tubes or post and sleeve arrangement separated by a minimum 1/2-inch- thick neoprene.

1. Factory-Set Height Guide with Shear Pin: Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.

2.11 AIR-SPRING ISOLATORS

A. Freestanding, Single or Multiple, Compressed-Air Bellows:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following :
   a. Ace Mountings Co., Inc.
   b. California Dynamics Corporation.
   c. Isolation Technology, Inc.
   d. Kinetics Noise Control, Inc.
   e. Mason Industries, Inc.
   f. Vibration Eliminator Co., Inc.
   g. Vibration Isolation.
   h. Vibration Mountings & Controls, Inc.

2. Bellows Assembly: Upper and lower powder-coated steel sections connected by a replaceable, flexible, nylon-reinforced neoprene bellows or similar elastomeric material.

3. Maximum Natural Frequency: 3 Hz.
4. Operating Pressure Range: 25 to 100 psig.
5. Burst Pressure: At least three times manufacturer's published maximum operating pressure.
6. Tank valves.

2.12 RESTRAINED-AIR-SPRING ISOLATORS

A. Freestanding, Single or Multiple, Compressed-Air Bellows with Vertical-Limit Stop Restraint:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following :
   a. Ace Mountings Co., Inc.
   b. California Dynamics Corporation.
   c. Isolation Technology, Inc.
   d. Kinetics Noise Control, Inc.
   e. Mason Industries, Inc.
   f. Vibration Eliminator Co., Inc.
   g. Vibration Isolation.
   h. Vibration Mountings & Controls, Inc.

2. Housing: Steel housing with vertical-limit stops to prevent spring extension due to weight being removed.

   a. Base with holes for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig.
   b. Top plate with threaded mounting holes or elastomeric pad.
   c. Internal leveling bolt that acts as blocking during installation.

3. Restraint: Limit stop as required for equipment and authorities having jurisdiction.
4. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
5. Minimum Additional Travel: 50 percent of the required deflection at rated load.
6. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
7. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
8. Bellows Assembly: Upper and lower powder-coated steel sections connected by a replaceable, flexible, nylon-reinforced neoprene bellows or similar elastomeric material.
9. Maximum Natural Frequency: 3 Hz.
10. Operating Pressure Range: 25 to 100 psig.
11. Burst Pressure: At least three times manufacturer's published maximum operating pressure.
12. Tank valves.

2.13 ELASTOMERIC HANGERS

A. Elastomeric Mount in a Steel Frame with Upper and Lower Steel Hanger Rods:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following :
   a. Ace Mountings Co., Inc.
   b. California Dynamics Corporation.
   c. Isolation Technology, Inc.
   d. Kinetics Noise Control, Inc.
   e. Mason Industries, Inc.
   f. Vibration Eliminator Co., Inc.
   g. Vibration Mountings & Controls, Inc.

2. Frame: Steel, fabricated with a connection for an upper threaded hanger rod and an opening on the underside to allow for a maximum of 30 degrees of angular lower hanger-rod misalignment without binding or reducing isolation efficiency.
3. Dampening Element: Molded, oil-resistant rubber, neoprene, or other elastomeric material with a projecting bushing for the underside opening preventing steel to steel contact.

2.14 SPRING HANGERS

A. Combination Coil-Spring and Elastomeric-Insert Hanger with Spring and Insert in Compression:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following :
   a. Ace Mountings Co., Inc.
   b. California Dynamics Corporation.
   c. Isolation Technology, Inc.
   d. Kinetics Noise Control, Inc.
   e. Mason Industries, Inc.
   f. Vibration Eliminator Co., Inc.
   g. Vibration Mountings & Controls, Inc.

2. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

7. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washerreinforced cup to support spring and bushing projecting through bottom of frame.
8. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
9. Self-centering hanger-rod cap to ensure concentricity between hanger rod and support spring coil.

2.15 SNUBBERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Kinetics Noise Control, Inc.
   2. Mason Industries, Inc.
   3. Vibration Mountings & Controls, Inc.

B. Description: Factory fabricated using welded structural-steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.
   1. Anchor bolts for attaching to concrete shall be seismic-rated, drill-in, and studwedge or female-wedge type.
   2. Resilient Isolation Washers and Bushings: Oil- and water-resistant neoprene.
   3. Maximum 1/4-inch air gap, and minimum 1/4-inch- thick resilient cushion.

2.16 RESTRAINT CHANNEL BRACINGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Cooper B-Line, Inc.
   2. Hilti, Inc.
   3. Mason Industries, Inc.
   4. Unistrut.

B. Description: MFMA-4, shop- or field-fabricated bracing assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosionresistant coating; rated in tension, compression, and torsion forces.

2.17 RESTRAINT CABLES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Kinetics Noise Control, Inc.
   2. Loos & Co., Inc.
   3. Vibration Mountings & Controls, Inc.

B. Restraint Cables: ASTM A 603 galvanized or ASTM A 492 stainless-steel cables. End connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; with a minimum of two clamping bolts for cable engagement.

2.18 SEISMIC-RESTRAINT ACCESSORIES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following :
   1. Cooper B-Line, Inc.
   2. Kinetics Noise Control, Inc.
   3. Mason Industries, Inc.
   4. TOLCO.

B. Hanger-Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections or reinforcing steel angle clamped to hanger rod.

C. Hinged and Swivel Brace Attachments: Multifunctional steel connectors for attaching hangers to rigid channel bracings and restraint cables.

D. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchor bolts and studs.

E. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices used.

F. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

2.19 MECHANICAL ANCHOR BOLTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following :
   1. Cooper B-Line, Inc.
   2. Hilti, Inc.
   3. Kinetics Noise Control, Inc.
   4. Mason Industries, Inc.

B. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinccoated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

2.20 ADHESIVE ANCHOR BOLTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following :
   1. Hilti, Inc.
   2. Kinetics Noise Control, Inc.
   3. Mason Industries, Inc.

B. Adhesive Anchor Bolts: Drilled-in and capsule anchor system containing PVC or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

2.21 RESTRAINED ISOLATION ROOF-CURB RAILS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Ace Mountings Co., Inc.
   2. California Dynamics Corporation.
   3. Kinetics Noise Control.
   4. Mason Industries, Inc.
   5. Thybar Corporation.

B. Description: Factory-assembled, fully enclosed, insulated, air- and watertight curb rail designed to resiliently support equipment and to withstand seismic and wind forces.

C. Upper Frame: The upper frame shall provide continuous support for equipment and shall be captive to resiliently resist seismic and wind forces.

D. Lower Support Assembly: The lower support assembly shall be formed sheet metal section containing adjustable and removable steel springs that support the upper frame. The lower support assembly shall have a means for attaching to building structure and a wood nailer for attaching roof materials, and shall be insulated with a minimum of 2 inches of rigid, glass-fiber insulation on inside of assembly. Adjustable, restrainedspring isolators shall be mounted on elastomeric vibration isolation pads and shall have access ports, for level adjustment, with removable waterproof covers at all isolator locations. Isolators shall be located so they are accessible for adjustment at any time during the life of the installation without interfering with the integrity of the roof.

E. Snubber Bushings: All-directional, elastomeric snubber bushings at least 1/4 inch thick.

F. Water Seal: Galvanized sheet metal with EPDM seals at corners, attached to upper support frame, extending down past wood nailer of lower support assembly, and counter flashed over roof materials.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive vibration isolation and seismic and windcontrol devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

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

D. Examine areas and equipment to receive seismic restraint devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

3.2 APPLICATIONS

A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an evaluation service member of ICC-ES and an agency acceptable to authorities having jurisdiction.

B. Hanger-Rod Stiffeners: Install hanger-rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.

C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength is adequate to carry present and future static and seismic loads within specified loading limits.

3.3 VIBRATION CONTROL AND SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 033000 "Cast-in-Place Concrete" and Section 033053 "Miscellaneous Cast-in-Place Concrete."

B. Installation of vibration isolators must not cause any change of position of equipment, piping, or ductwork resulting in stresses or misalignment.

C. Comply with requirements in Section 077200 "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations. D. Equipment Restraints:

1. Install seismic snubbers on HVAC equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.
2. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.

3. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES and an agency acceptable to authorities having jurisdiction that provides required submittals for component. E. Piping Restraints:

1. Comply with requirements in MSS SP-127.
2. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.
3. Brace a change of direction longer than 12 feet.

F. Install cables so they do not bend across edges of adjacent equipment or building structure.

G. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES and an agency acceptable to authorities having jurisdiction that provides required submittals for component.

H. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.

I. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

J. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

K. Drilled-in Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavyduty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
5. Set anchors to manufacturer's recommended torque, using a torque wrench.
6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.4 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Install flexible connections in piping where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment. Comply with requirements in Section 232113 "Hydronic Piping" for piping flexible connections.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Tests and Inspections:

1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.
3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
4. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
5. Test to 90 percent of rated proof load of device.
6. Measure isolator restraint clearance.
7. Measure isolator deflection.
8. Verify snubber minimum clearances.
9. Test and adjust restrained-air-spring isolator controls and safeties. D. Remove

and replace malfunctioning units and retest as specified above.

E. Prepare test and inspection reports.

3.6 ADJUSTING

A. Adjust isolators after piping system is at operating weight.

B. Adjust limit stops on restrained-spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

3.7 AIR-SPRING ISOLATOR INSTALLATION

A. Independent Isolator Installation:

1. Install tank valve into each air isolator.
2. Inflate each isolator to height and pressure specified on Drawings. B.

Pressure-Regulated Isolator Installation:

1. Coordinate the constant pressure-regulated air supply to air springs with the requirements for piping and connections specified in Section 221513 "GeneralService Compressed-Air Piping."
2. Connect all pressure regulators to a single dry, filtered facility or constant air supply.
3. Inflate isolators to height and pressure specified on Drawings.

3.9 VIBRATION ISOLATION SCHEDULES

A. Provide vibration isolators and equipment bases for all rotating, piston driven or vibrating equipment in accordance with the following schedules. Selection of equipment isolators shall be based on approved equipment shop drawings.

Base & Isolator Types			
Base Types		pes	
A	No base, isolators attached directly to equipment.	1	Elastomeric pad.
B	Structural steel rails or base.	2	Elastomeric floor mount or hanger. Use restrained elastomeric mount where seismic restraint is required.
C	Concrete inertia base.	3	Spr ing floor isolator or hanger.
D	Curb-mounted base.	4	Restrained spring isolator.
		5	Thrust restraint.

Vibration Isolation - Refrigeration Machines and Chillers

Compressor Type	Horsepower and Other	RPM	Floor Span: Slab on Grade			Up to 20 ft			20 to 30 ft			30 to 40 ft			Table Notes
			Base Type	Isolator Type	Min Defl., (in.)	Base Type	Isolator Type	Min Defl., (in.)	Base Type	Isolator Type	Min Defl., (in.)	Base Type	Isolator Type	Min Defl., (in.)	
Water Cooled Reciprocating	All	All	A	2	0.25	A	4	0.75	A	4	1.5	A	4	2.5	1
Water Cooled Centrifugal, Scroll	All	All	A	1	0.25	A	4	0.75	A	4	1.5	A	4	1.5	1,2,3
Water Cooled Centrifugal, Screw	All	All	A	1	1.0	A	4	1.5	A	4	2.5	A	4	2.5	1,2
Absorption	All	All	A	4	0.25	A	4	0.75	A	4	1.5	A	4	1.5	
Air Cooled, Reciprocating, Scroll	All	All	A	1	0.25	A	4	1.5	A	4	1.5	A	4	2.5	1,2,4
Air Cooled, Reciprocating, Screw	All	All	A	4	1.0	A	4	1.5	B	4	2.5	B	4	2.5	1,2,3,4

Notes:
1. Increase isolator deflection so isolator stiffness is less than one-tenth the stiffness of the supporting structure, as defined by the deflection due to load at the equipment support.
2. Where equipment manufacturer indicates component cannot be installed directly on individual isolators (type A), provide equipment manufacturer recommended supplemental support (base type).
3. Select isolator deflection so that resonance frequency is 40 percent or less of the lowest normal operating speed of equipment. Add a 1 in. thick pad (type 1) to the base plate of spring isolators (type 3).
4. Provide restrained isolators, supplemental bracing and snubbers required to account for wind loading conditions.

Vibration Isolation - Air Compressors

Compressor Type	Horsepower and Other	RPM	Floor Span: Slab on Grade			Up to 20 ft			20 to 30 ft			30 to 40 ft			Table Notes
			Base Type	Isolator Type	Min Defl., (in.)	Base Type	Isolator Type	Min Defl., (in.)	Base Type	Isolator Type	Min Defl., (in.)	Base Type	Isolator Type	Min Defl., (in.)	
Tank- mounted horizontal	≤10	All	A	3	0.75	A	3	0.75	A	3	1.5	A	3	1.5	1
	≥15	All	C	3	0.75	C	3	0.75	C	3	1.5	C	3	1.5	1
Tank- mounted vertical	All	All	C	3	0.75	C	3	0.75	C	3	1.5	C	3	1.5	1
Base- Mounted	All	All	C	3	0.75	C	3	0.75	C	3	1.5	C	3	1.5	1,2
Large Reciprocating	All	All	C	3	0.75	C	3	0.75	C	3	1.5	C	3	1.5	1,2

Notes:

1. Compressors: Install base-mounted compressors through 5 hp and horizontal tank-type air compressors through 10 hp directly on spring isolators (type 3) with structural bases (type B), and compressors 15 to 100 hp on spring isolators (type 3) with inertia bases (type C) weighing 1 to 2 times the compressor weight.
2. When using Y, W, and multi-head and multi-cylinder compressors, obtain the magnitude of unbalanced forces from the equipment manufacturer for use in assessing need for an inertia base.

Vibration Isolation - Pumps

Pump Type	Horsepower and Other	RPM	Floor Span												Table Notes
			Slab on Grade			Up to 20 ft			20 to 30 ft			30 to 40 ft			
			Base Type	Isolator Type	Min Defl., (in.)	Base Type	Isolator Type	Min Defl., (in.)	Base Type	Isolator Type	Min Defl., (in.)	Base Type	Isolator Type	Min Defl., (in.)	
Close Coupled	≤7.5	All	B	2	0.25	C	3	0.75	C	3	0.75	C	3	0.75	1
	≥10	All	C	3	0.75	C	3	0.75	C	3	1.5	C	3	1.5	1
Large Inline	5 to 25	All	A	3	0.75	A	3	1.5	A	3	1.5	A	2	1.5	
	≥30	All	A	3	1.5	A	3	1.5	A	3	1.5	A	3	2.5	
End suction and split case	≤40	All	C	3	0.75	C	3	0.75	C	3	1.5	C	3	1.5	1
	50 to 125	All	C	3	0.75	C	3	0.75	C	3	1.5	C	3	2.5	1
	≥150	All	C	3	0.75	C	3	0.75	C	3	2.5	C	3	3.5	1
Packaged Pump Systems	All	All	A	3	0.75	A	3	0.75	A	3	1.5	C	3	2.5	

Notes:

1. Pumps: Type C bases strength and shape shall accommodate base elbow supports. Concrete bases (type C) shall be designed for a thickness of one-tenth the longest dimension with minimum thickness as follows: (1) for up to 30 hp, 6 in.; (2) for 40 to 75 hp, 8 in.; and (3) for 100 hp and up, 12 in. Pumps over 75 hp and multistage pumps shall be provided with supplemental restraining devices.

Vibration Isolation - Cooling Towers

Tower Type	Horsepower and Other	Min. RPM	Floor Span												Table Notes
			Slab on Grade			Up to 20 ft			20 to 30 ft			30 to 40 ft			
			Base Type	Isolator Type	Min Defl., (in.)	Base Type	Isolator Type	Min Defl., (in.)	Base Type	Isolator Type	Min Defl., (in.)	Base Type	Isolator Type	Min Defl., (in.)	
All	All	Up to 300	B	1	0.25	B	4	3.5	B	4	3.5	B	4	3.5	1,2,3
		301 to 500	B	1	0.25	B	4	2.5	B	4	2.5	B	4	2.5	1,3
		500 and up	B	1	0.25	B	4	0.75	B	4	0.75	B	4	1.5	1.3

Notes:

1. Provide restrained spring isolators (type 4), supplemental bracing, snubbers, or limit stops to address wind loading.
2. Select isolator deflection so that resonance frequency is 40 percent or less of the lowest normal operating speed of equipment. Add a 1 in. thick pad (type 1) to the base plate of spring isolators (type 4).

3. Provide structural steel rails to support multiple cooling tower cells as a single unit. Size rails for equipment support and span between isolators. Iso- late with restrained spring isolators mounted between continuous steel rail and building structural supports. Design of rail and isolator locations and attachment methods shall be provided by vibration isolation manufacturer.

Vibration Isolation - Boilers and Steam Generators

Boiler Type	Horsepower and Other	RPM	Floor Span												Table Notes
			Slab on Grade			Up to 20 ft			20 to 30 ft			30 to 40 ft			
			Base Type	Isolator Type	Min Defl., (in.)	Base Type	Isolator Type	Min Defl., (in.)	Base Type	Isolator Type	Min Defl., (in.)	Base Type	Isolator Type	Min Defl., (in.)	
Fire-tube	All	All	A	1	0.25	B	4	0.75	B	4	1.5	B	4	2.5	1
Water-tube, copper Fin	All	All	A	1	0.12	A	1	0.12	A	1	0.12	B	4	0.25	1

Notes:
1. Where equipment manufacturer indicates component cannot be installed directly on individual isolators (type A) provide equipment manufacturer recommended supplemental support (base type).

Vibration Isolation - Axial Fans, Fan Heads, Cabinet Fans, Fan Sections

Fan Size	Fan Static Pressure	RPM	Floor Span												Table Notes
			Slab on Grade			Up to 20 ft			20 to 30 ft			30 to 40 ft			
			Base Type	Isolator Type	Min Defl., (in.)	Base Type	Isolator Type	Min Defl., (in.)	Base Type	Isolator Type	Min Defl., (in.)	Base Type	Isolator Type	Min Defl., (in.)	
Up to 22 in. diameter	All	All	A	2	0.25	A	3	0.75	A	3	0.75	C	3	0.75	1,2,3
24 in. diameter & up	≤2 in. SP	Up to 300	B	3	2.5	C	3	3.5	C	3	3.5	C	3	3.5	2,3
		300 to 500	B	3	0.75	B	3	1.5	C	3	2.5	C	3	2.5	2,3
		501 and up	B	3	0.75	B	3	1.5	B	3	1.5	B	3	1.5	2,3
	≥2.1 in. SP	Up to 300	C	3	2.5	C	3	3.5	C	3	3.5	C	3	3.5	2,3
		300 to 500	C	3	1.5	C	3	1.5	C	3	2.5	C	3	2.5	2,3
		501 and up	C	3	0.75	C	3	1.5	C	3	1.5	C	3	2.5	2.3

Notes:

1. Where equipment manufacturer indicates component cannot be installed directly on individual isolators (type A) provide equipment manufacturer recommended supplemental support (base type).
2. Select isolator deflection so that resonance frequency is 40 percent or less of the lowest normal operating speed of equipment. Add a 1 in. thick pad (type 1) to the base plate of spring isolators (type 3).
3. To limit undesirable movement, thrust restraints (type 5) are required for all ceiling-suspended and floor-mounted units operating at 2 in. of water or more total static pressure.

Vibration Isolation - Centrifugal Fans

Fan Size	Fan Horsepower	RPM	Floor Span												Table Notes
			Slab on Grade			Up to 20 ft			20 to 30 ft			30 to 40 ft			
			Base Type	Isolator Type	Min Defl., (in.)	Base Type	Isolator Type	Min Defl., (in.)	Base Type	Isolator Type	Min Defl., (in.)	Base Type	Isolator Type	Min Defl., (in.)	
Up to 22 in. diameter	All	All	B	2	0.25	B	3	0.75	B	3	0.75	B	3	1.5	3,4
24 in. diameter & up	≤40	Up to 300	B	3	2.5	B	3	3.5	B	3	3.5	B	3	3.5	2,4
		300 to 500	B	3	1.5	B	3	1.5	B	3	2.5	B	3	2.5	2,4
		501 and up	B	3	0.75	B	3	0.75	B	3	0.75	B	3	1.5	2,4
	≥50	Up to 300	C	3	2.5	C	3	3.5	C	3	3.5	C	3	3.5	1,2,3,4
		300 to 500	C	3	1.5	C	3	1.5	C	3	2.5	C	3	2.5	1,2,3,4
		501 and up	C	3	1.0	C	3	1.5	C	3	1.5	C	3	2.5	1,2,3,4,

Notes:

1. Increase isolator deflection so isolator stiffness is less than one-tenth the stiffness of the supporting structure, as defined by the deflection due to load at the equipment support.
2. Select isolator deflection so that resonance frequency is 40 percent or less of the lowest normal operating speed of equipment. Add a 1 in. thick pad (type 1) to the base plate of spring isolators (type 3).
3. Provide thrust restraints (type 5) for all ceiling-suspended and floor-mounted units operating at 2 in. of water or more total static pressure.
4. Fans and Air-Handling Equipment: For fans operating under 300 rpm, select isolator deflection so the isolator natural frequency is 40 percent or less than the fan speed. Flexible duct connectors shall be installed at the intake and discharge of all fans and air-handling equipment to reduce vibration transmission to air duct structures. Provide inertia bases (type C) for all class 2 and 3 fans and air handling equipment. Provide thrust restraints (type 5) with same deflection as isolators for all fans and all base-mounted and suspended air-handling equipment operating at 2 in. or more total static pressure. Adjust restraint movement under normal operational static pressures.

Vibration Isolation - Propeller Fans															
Fan Type	Horsepower and Other	RPM	Floor Span												Table Notes
			Slab on Grade			Up to 20 ft			20 to 30 ft			30 to 40 ft			
			Base Type	Isolator Type	Min Defl., (in.)	Base Type	Isolator Type	Min Defl., (in.)	Base Type	Isolator Type	Min Defl., (in.)	Base Type	Isolator Type	Min Defl., (in.)	
Wall-mounted	All	All	A	A	0.25	A	1	0.25	A	1	0.25	A	1	0.25	
Roof-mounted	All	All	A	A	0.25	A	1	0.25	B	4	1.5	D	4	1.5	

Vibration Isolation - Heat Pumps, Fan Coil Units and Computer Room Units															
Equipment Type	Horsepower and Other	RPM	Floor Span												Table Notes
			Slab on Grade			Up to 20 ft			20 to 30 ft			30 to 40 ft			
			Base Type	Isolator Type	Min Defl., (in.)	Base Type	Isolator Type	Min Defl., (in.)	Base Type	Isolator Type	Min Defl., (in.)	Base Type	Isolator Type	Min Defl., (in.)	
Heat Pumps, Fan Coil Units and Computer Room Units	All	All	A	3	0.75	A	3	0.75	A	3	0.75	A/D	3	1.5	

Vibration Isolation - Condensing Units															
Equipment Type	Horsepower and Other	RPM	Floor Span												Table Notes
			Slab on Grade			Up to 20 ft			20 to 30 ft			30 to 40 ft			
			Base Type	Isolator Type	Min Defl., (in.)	Base Type	Isolator Type	Min Defl., (in.)	Base Type	Isolator Type	Min Defl., (in.)	Base Type	Isolator Type	Min Defl., (in.)	
Condensing Units	All	All	A	1	0.25	A	4	0.75	A	4	1.5	A/D	4	1.5	

Vibration Isolation - Packaged Air Handling Unit, Air Conditioning Units, Heating & Ventilating Units

Fan Size	Fan HP, Static Pressure	RPM	Floor Span												Table Notes
			Slab on Grade			Up to 20 ft			20 to 30 ft			30 to 40 ft			
			Base Type	Isolator Type	Min Defl., (in.)	Base Type	Isolator Type	Min Defl., (in.)	Base Type	Isolator Type	Min Defl., (in.)	Base Type	Isolator Type	Min Defl., (in.)	
All	≤10	All	A	3	0.75	A	3	0.75	A	3	0.75	A	3	0.75	5,6
	≥15, ≤4 in. SP	Up to 300	A	3	0.75	A	3	3.5	A	3	3.5	C	3	3.5	1,3,4,5,6
		300 to 500	A	3	0.75	A	3	2.5	A	3	2.5	A	3	2.5	3,5,6
		501 and up	A	3	0.75	A	3	1.5	A	3	1.5	A	3	1.5	3,5,6
	≥15, ≥4 in. SP	Up to 300	B	3	0.75	C	3	3.5	C	3	3.5	C	3	3.5	1,2,3,4,5
		300 to 500	B	3	0.75	C	3	1.5	C	3	2.5	C	3	2.5	1,2,3,5
		501 and up	B	3	0.75	C	3	1.5	C	3	1.5	C	3	2.5	1,2,3,5

Notes:
1. Where available, use of packaged equipment manufacturer internal isolators meeting the above requirements is acceptable. Coordinate with equip- ment manufacturer. Provide documentation in both equipment submittals and in submittals for this Section.
2. Increase isolator deflection so isolator stiffness is less than one-tenth the stiffness of the supporting structure, as defined by the deflection due to load at the equipment support.
3. Where equipment manufacturer indicates component cannot be installed directly on individual isolators (type A) provide equipment manufacturer rec- ommended supplemental support (base type).
4. Select isolator deflection so that resonance frequency is 40 percent or less of the lowest normal operating speed of equipment. Add a 1 in. thick pad (type 1) to the base plate of spring isolators (type 3).
5. Provide thrust restraints (type 5) for all ceiling-suspended and floor-mounted units operating at 2 in. of water or more total static pressure.
6. Fans and Air-Handling Equipment: For fans operating under 300 rpm, select isolator deflection so the isolator natural frequency is 40 percent or less than the fan speed. Flexible duct connectors shall be installed at the intake and discharge of all fans and air-handling equipment to reduce vibration transmission to air duct structures. Provide inertia bases (type C) for all class 2 and 3 fans and air handling equipment. Provide thrust restraints (type 5) with the same deflection as isolators for all fans and all base-mounted and suspended air-handling equipment operating at 2 in. or more total static pressure. Adjust restraint movement under normal operational static pressures.

Vibration Isolation - Packaged Rooftop Air Conditioning Equipment

	Fan HP,		Floor Span				
			Slab on Grade	Up to 20 ft	20 to 30 ft	30 to 40 ft	

Fan Size	Static Pressure	RPM	Base Type	Isolator Type	Min Defl., (in.)	Base Type	Isolator Type	Min Defl., (in.)	Base Type	Isolator Type	Min Defl., (in.)	Base Type	Isolator Type	Min Defl., (in.)	Table Notes
All	All	All	A/D	1	0.25	D	3	0.75	DO NOT ALLOW						1,2,3

Notes:

1. Provide restrained isolators, supplemental bracing and snubbers required to account for wind loading conditions.
2. Provide curbs where indicated and where manufacturer of equipment requires curb mounting.
3. Select isolator deflection so that resonance frequency is 40 percent or less of the lowest normal operating speed of equipment. Add a 1 in. thick pad (type 1) to the base plate of spring isolators (type 3).
4. Use of packaged equipment manufacturer internal isolators meeting the above requirements is acceptable. Coordinate with equipment manufacturer. Provide documentation in both equipment submittals and in submittals for this Section.

Vibration Isolation - Ducted Rotating Equipment

Equipment Type	Airflow (cfm)	RPM	Floor Span												Table Notes
			Slab on Grade			Up to 20 ft			20 to 30 ft			30 to 40 ft			
			Base Type	Isolator Type	Min Defl., (in.)	Base Type	Isolator Type	Min Defl., (in.)	Base Type	Isolator Type	Min Defl., (in.)	Base Type	Isolator Type	Min Defl., (in.)	
Small fans, fan- powered boxes, cabinet heaters, unit heaters	≤600	All	A	3	0.5	A	3	0.5	A	3	0.5	A	3	0.5	
	≥601	All	A	3	0.75	A	3	0.75	A	3	0.75	A	3	0.75	

Vibration Isolation - Engine-Driven Generators

Generator Type	Horsepower and Other	RPM	Floor Span												Table Notes
			Slab on Grade			Up to 20 ft			20 to 30 ft			30 to 40 ft			
			Base Type	Isolator Type	Min Defl., (in.)	Base Type	Isolator Type	Min Defl., (in.)	Base Type	Isolator Type	Min Defl., (in.)	Base Type	Isolator Type	Min Defl., (in.)	
All	All	All	A	3	0.75	C	3	1.5	C	3	2.5	C	3	3.5	1,2

Notes:

1. Increase isolator deflection so isolator stiffness is less than one-tenth the stiffness of the supporting structure, as defined by the deflection due to load at the equipment support.
2. Where equipment manufacturer indicates component cannot be installed directly on individual isolators (type A) provide equipment manufacturer recommended supplemental support (base type).

3.10 PIPING SYSTEM VIBRATION ISOLATION

A. Vibration isolators for suspended piping:

1. Provide spring hangers for all piping in equipment rooms and up to 50 ft from vibration- isolated equipment and PRV stations. The first three hangers from the equipment shall be provided with the same deflection as the equipment isolators, with a maximum limitation of 2 in. deflection. Remaining hangers shall be spring or combination spring and elastomeric with 0.75 in. deflection. The first two hangers adjacent to the equipment shall be the positioning or pre-compressed type. Provide positioning hangers for all isolated piping 8 in. and larger. Piping over 2 inches in diameter suspended below or within 50 ft of conference rooms, classrooms and auditorium areas shall be hung with isolation hangers. B. Vibration isolators for floor-supported piping:

1. Provide vibration isolators for floor supports for piping in equipment rooms to isolate equipment. Isolators shall be selected according to the guidelines for hangers. The first two adjacent floor supports shall be the restrained spring type, with a restraint/blocking feature to prevent load transfer to equipment flanges as the piping is filled or drained. Provide a slide plate where pipe is subjected to large thermal movement (PTFE, graphite, or steel) and shall be installed on top of the isolator. Provide a thermal barrier when rubber products are installed directly beneath steam or hot-water lines.

C. Vibration isolation for piping riser supports:

1. Provide resilient pipe riser support near to midpoint of riser and provide spring hangers at each floor or structural level to support riser and allow thermal expansion risers.
2. Provide spring hangers for first three hangers connected to branch piping at each level.

END OF SECTION

SECTION 230553
IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Equipment labels.
2. Warning signs and labels.
3. Pipe labels.
4. Duct labels.
5. Stencils.
6. Valve tags.
7. Warning tags.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Samples: For color, letter style, and graphic representation required for each identification material and device.

C. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label. D. Valve numbering scheme.

E. Valve Schedules: For each piping system to include in maintenance manuals.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Metal Labels for Equipment:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. Brady Corporation.
   b. Marking Services, Inc.
   c. Seton Identification Products.

2. Material and Thickness: Brass, 0.032-inch or stainless steel, 0.025-inch or anodized aluminum, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
3. Letter Color: Black or White
4. Background Color: Blue or Yellow
5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
7. Fasteners: Stainless-steel rivets or self-tapping screws.
8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Plastic Labels for Equipment:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following: a. Brady Corporation.

b. Marking Services, Inc.
c. Seton Identification Products.

2. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.
3. Letter Color: Black or White.
4. Background Color: Blue or Yellow.
5. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
6. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
7. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
8. Fasteners: Stainless-steel rivets or self-tapping screws.
9. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

C. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), and the Specification Section number and title where equipment is specified.

D. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by11-inch bond paper. Tabulate equipment identification number, and identify Drawing numbers where equipment is indicated (plans, details, and schedules) and the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.2 WARNING SIGNS AND LABELS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
1. Brady Corporation.
2. Marking Services, Inc.
3. Seton Identification Products.

B. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware. C. Letter Color: Black or White.

D. Background Color: Blue or Yellow.

E. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

F. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

G. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.

H. Fasteners: Stainless-steel rivets or self-tapping screws.

I. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

J. Label Content: Include caution and warning information plus emergency notification instructions.

2.3 PIPE LABELS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   1. Brady Corporation.
   2. Marking Services, Inc.
   3. Seton Identification Products.

B. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction according to ASME A13.1.

C. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to partially cover or cover full circumference of pipe and to attach to pipe without fasteners or adhesive.

D. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

E. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings; also include pipe size and an arrow indicating flow direction.

   1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions or as separate unit on each pipe label to indicate flow direction.
   2. Lettering Size: Size letters according to ASME A13.1 for piping and At least 1/2 inch for viewing distances up to 72 inches and proportionately larger lettering for greater viewing distances.

2.4 DUCT LABELS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
1. Brady Corporation.
2. Marking Services, Inc.
3. Seton Identification Products.

B. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware. C. Letter Color: Black.

D. Background Color: White.

E. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

F. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

G. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.

H. Fasteners: Stainless-steel rivets or self-tapping screws.

I. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

J. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings; also include duct size and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with duct system service lettering to accommodate both directions or as separate unit on each duct label to indicate flow direction.

2.5 STENCILS

A. Stencils for Piping:

1. Lettering Size: Size letters according to ASME A13.1 for piping and At least 1/2 inch for viewing distances up to 72 inches and proportionately larger lettering for greater viewing distances.
2. Stencil Material: Aluminum, Brass or metal.

3. Stencil Paint: Exterior, gloss, alkyd enamel or acrylic enamel in colors complying with recommendations in ASME A13.1 unless otherwise indicated. Paint may be in pressurized spray-can form.
4. Identification Paint: Exterior, alkyd enamel or acrylic enamel in colors according to ASME A13.1 unless otherwise indicated. Paint may be in pressurized spray-can form.

B. Stencils for Ducts:
1. Lettering Size: Minimum letter height of 1-1/4 inches for viewing distances up to 15 feet and proportionately larger lettering for greater viewing distances.
2. Stencil Material: Aluminum, Brass or metal.
3. Stencil Paint: Exterior, gloss, alkyd enamel or acrylic enamel. Paint may be in pressurized spray-can form.
4. Identification Paint: Exterior, alkyd enamel or acrylic enamel. Paint may be in pressurized spray-can form.

C. Stencils for Access Panels and Door Labels, Equipment Labels, and Similar Operational Instructions:
1. Lettering Size: Minimum letter height of 1/2 inch for viewing distances up to 72 inches and proportionately larger lettering for greater viewing distances.
2. Stencil Material: Aluminum, Brass or metal.
3. Stencil Paint: Exterior, gloss, alkyd enamel or acrylic enamel. Paint may be in pressurized spray-can form.
4. Identification Paint: Exterior, alkyd enamel or acrylic enamel. Paint may be in pressurized spray-can form.

2.6 VALVE TAGS

A. Description: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.
1. Tag Material: Brass, 0.032-inch or stainless steel, 0.025-inch or anodized aluminum, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Fasteners: Brass wire-link chain or beaded chain or S-hook.

B. Valve Schedules: For each piping system, on 8-1/2-by-11-inch bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.

1. Valve-tag schedule shall be included in operation and maintenance data.

2.7 WARNING TAGS

A. Description: Preprinted or partially preprinted accident-prevention tags of plasticized card stock with matte finish suitable for writing.

1. Size: Approximately 4 by 7 inches.
2. Fasteners: Brass grommet and wire or Reinforced grommet and wire or string.
3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
4. Color: Safety-yellow background with black lettering.

PART 3 - EXECUTION

3.1 PREPARATION

A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.2 GENERAL INSTALLATION REQUIREMENTS

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

B. Coordinate installation of identifying devices with locations of access panels and doors.

C. Install identifying devices before installing acoustical ceilings and similar concealment.

3.3 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of mechanical equipment.
B. Locate equipment labels where accessible and visible.

3.4 PIPE LABEL INSTALLATION

A. Piping Color Coding: Painting of piping is specified in Section 099123 "Interior Painting" and Section 099600 "High-Performance Coatings."

B. Stenciled Pipe Label Option: Stenciled labels may be provided instead of manufactured pipe labels, at Installer's option. Install stenciled pipe labels, complying with ASME A13.1, with painted, color-coded bands or rectangles on each piping system.

1. Identification Paint: Use for contrasting background.
2. Stencil Paint: Use for pipe marking.

C. Pipe Label Locations: Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:

1. Near each valve and control device.
2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations and on both sides of through walls, floors, ceilings, and inaccessible enclosures.
4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.
7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

D. Directional Flow Arrows: Arrows shall be used to indicate direction of flow in pipes, including pipes where flow is allowed in both directions. E. Pipe Label Color Schedule:

1. Chilled-Water Piping: Black letters on a safety-orange background.
2. Heating Water Piping: Black letters on a safety-orange background.
3. Refrigerant Piping: Black letters on a safety-white background.
4. Low-Pressure Steam Piping: White letters on a safety-gray background.
5. High-Pressure Steam Piping: White letters on a safety-purple background.
6. Steam Condensate Piping: White letters on a safety-black background.

3.5 DUCT LABEL INSTALLATION

A. Install plastic-laminated or self-adhesive duct labels with permanent adhesive on air ducts in the following color codes:

1. Blue: For cold-air supply ducts.
2. Yellow: For hot-air supply ducts.
3. Green: For exhaust-, outside-, relief-, return-, and mixed-air ducts.

B. Stenciled Duct Label Option: Stenciled labels showing service and flow direction may be provided instead of plastic-laminated duct labels, at Installer's option.

C. Locate labels near points where ducts enter into and exit from concealed spaces and at maximum intervals of 50 feet in each space where ducts are exposed or concealed by removable ceiling system.

3.6 VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in piping systems, except check valves, valves within factory-fabricated equipment units, shutoff valves, faucets, convenience and lawn-watering hose connections, and HVAC terminal devices and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.

B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:

1. Valve-Tag Size and Shape:

    a. Chilled Water: 1-1/2 inches or 2 inches, round or square.
    b. Condenser Water: 1-1/2 inches or 2 inches, round or square.
    c. Refrigerant: 1-1/2 inches or 2 inches, round or square.
    d. Hot Water: 1-1/2 inches or 2 inches, round or square.
    e. Gas: 1-1/2 inches or 2 inches, round or square.
    f. Low-Pressure Steam: 1-1/2 inches or 2 inches, round or square.
    g. High-Pressure Steam: 1-1/2 inches or 2 inches, round or square.
    h. Steam Condensate: 1-1/2 inches or 2 inches, round or square.

2. Valve-Tag Colors:

    a. Toxic and Corrosive Fluids: Black letters on a safety-orange background.
    b. Flammable Fluids: Black letters on a safety-yellow background.
    c. Combustible Fluids: White letters on a safety-brown background.
    d. Potable and Other Water: White letters on a safety-green background.
    e. Compressed Air: White letters on a safety-blue background.
    f. Defined by User: White letters on a safety-purple background, black letters on a safety-white background, white letters on a safety-gray background, and white letters on a safety-black background

3.7 WARNING-TAG INSTALLATION

A. Write required message on, and attach warning tags to, equipment and other items where required.

END OF SECTION

SECTION 230593
TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Balancing Air Systems:

   a. Constant-volume air systems.
   b. Variable-air-volume systems.

2. Balancing Hydronic Piping Systems:

   a. Constant-flow hydronic systems.
   b. Variable-flow hydronic systems.

3. Balancing steam systems.
4. Testing, Adjusting, and Balancing Equipment:
   a. Motors.
   b. Chillers.
   c. Condensing units.
   d. Heat-transfer coils.

5. Testing, adjusting, and balancing existing systems and equipment.
6. Sound tests.
7. Vibration tests.
8. Duct leakage tests.
9. Control system verification.

1.3 DEFINITIONS

A. AABC: Associated Air Balance Council.

B. BAS: Building automation systems.

C. NEBB: National Environmental Balancing Bureau.

D. TAB: Testing, adjusting, and balancing.
E. TABB: Testing, Adjusting, and Balancing Bureau.

F. TAB Specialist: An independent entity meeting qualifications to perform TAB work.

G. TDH: Total dynamic head.

1.4 PREINSTALLATION MEETINGS

A. TAB Conference: If requested by the Owner, conduct a TAB conference after approval of the TAB strategies and procedures plan to develop a mutual understanding of the details. Provide a minimum of 14 days' advance notice of scheduled meeting time and location.

1. Minimum Agenda Items:

    a. The Contract Documents examination report.
    b. The TAB plan.
    c. Needs for coordination and cooperation of trades and subcontractors.
    d. Proposed procedures for documentation and communication flow.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: Within **30** days of Contractor's Notice to Proceed, submit documentation that the TAB specialist and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.

B. Contract Documents Examination Report: Within 30 days of Contractor's Notice to Proceed, submit the Contract Documents review report as specified in Part 3.

C. Strategies and Procedures Plan: Within 30 days of Contractor's Notice to Proceed, submit TAB strategies and step-by-step procedures as specified in "Preparation" Article.

D. System Readiness Checklists: Within 30 days of Contractor's Notice to Proceed, submit system readiness checklists as specified in "Preparation" Article.

E. Examination Report: Submit a summary report of the examination review required in "Examination" Article. F. Certified TAB reports.

G. Sample report forms.

H. Instrument calibration reports, to include the following:

1. Instrument type and make.
2. Serial number.
3. Application.

4. Dates of use.
5. Dates of calibration.

1.6 PROJECT CONDITIONS

A. Full Owner Occupancy: Owner will occupy the site and existing building during entire TAB period. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

B. Partial Owner Occupancy: Owner may occupy completed areas of building before Substantial Completion. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

1.7 COORDINATION

A. Notice: Provide **seven** days' advance notice for each test. Include scheduled test dates and times.

B. Perform TAB after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.

1.8 QUALITY ASSURANCE

A. TAB Specialists Qualifications: Certified by AABC.

1. TAB Field Supervisor: Employee of the TAB specialist and certified by AABC.
2. TAB Technician: Employee of the TAB specialist and certified by AABC as a TAB technician.

B. TAB Specialists Qualifications: Certified by NEBB or TABB.

1. TAB Field Supervisor: Employee of the TAB specialist and certified by NEBB or TABB.
2. TAB Technician: Employee of the TAB specialist and certified by NEBB or TABB as a TAB technician.

C. Instrumentation Type, Quantity, Accuracy, and Calibration: Comply with requirements in ASHRAE 111, Section 4, "Instrumentation."

D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.7.2.3 - "System Balancing."

1.9 FIELD CONDITIONS

A. Full Owner Occupancy: Owner will occupy the site and existing building during entire TAB period. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

B. Partial Owner Occupancy: Owner may occupy completed areas of building before Substantial Completion. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 TAB SPECIALISTS

A. Subject to compliance with requirements, engage one of the following:

1) THERMAL THINKERS INC.

2) INTERNATIONAL TESTING & BALANCING, LTD.

3) METROPOLITAN TESTING AND BALANCING OF COLLEGE POINT, NY

4) ALL CITY TESTING & BALANCING CORP.

5) NATIONAL AIR FILTERS

3.2 EXAMINATION

A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems designs that may preclude proper TAB of systems and equipment.

B. Examine installed systems for balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are applicable for intended purpose and are accessible.

C. Examine the approved submittals for HVAC systems and equipment.

D. Examine design data including HVAC system descriptions, statements of design assumptions for environmental conditions and systems output, and statements of philosophies and assumptions about HVAC system and equipment controls.

E. Examine ceiling plenums and underfloor air plenums used for supply, return, or relief air to verify that they are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed and fire-stopped if required.

F. Examine equipment performance data including fan and pump curves.

1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.

G. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.

H. Examine test reports specified in individual system and equipment Sections.

I. Examine HVAC equipment and verify that bearings are greased, belts are aligned and tight, filters are clean, and equipment with functioning controls is ready for operation.

J. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible and their controls are connected and functioning.

K. Examine strainers. Verify that startup screens have been replaced by permanent screens with indicated perforations.

L. Examine control valves for proper installation for their intended function of throttling, diverting, or mixing fluid flows.

M. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

N. Examine system pumps to ensure absence of entrained air in the suction piping.

O. Examine operating safety interlocks and controls on HVAC equipment.

P. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.3 PREPARATION

A. Prepare a TAB plan that includes the following:

1. Equipment and systems to be tested.
2. Strategies and step-by-step procedures for balancing the systems.
3. Instrumentation to be used.
4. Sample forms with specific identification for all equipment.

B. Perform system-readiness checks of HVAC systems and equipment to verify system readiness for TAB work. Include, at a minimum, the following:

1. Airside:

   a. Verify that leakage and pressure tests on air distribution systems have been satisfactorily completed.
   b. Duct systems are complete with terminals installed.
   c. Volume, smoke, and fire dampers are open and functional.
   d. Clean filters are installed.
   e. Fans are operating, free of vibration, and rotating in correct direction.
   f. Variable-frequency controllers' startup is complete and safeties are verified.
   g. Automatic temperature-control systems are operational.
   h. Ceilings are installed.
   i. Windows and doors are installed.
   j. Suitable access to balancing devices and equipment is provided.

2. Hydronics:

   a. Verify leakage and pressure tests on water distribution systems have been satisfactorily completed.
   b. Piping is complete with terminals installed.
   c. Water treatment is complete.
   d. Systems are flushed, filled, and air purged.
   e. Strainers are pulled and cleaned.
   f. Control valves are functioning per the sequence of operation.
   g. Shutoff and balance valves have been verified to be 100 percent open.
   h. Pumps are started and proper rotation is verified.
   i. Pump gage connections are installed directly at pump inlet and outlet flanges or in discharge and suction pipe prior to valves or strainers.
   j. Variable-frequency controllers' startup is complete and safeties are verified.
   k. Suitable access to balancing devices and equipment is provided.

3.4 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 Total System Balance", ASHRAE 111, NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and SMACNA's "HVAC Systems - Testing, Adjusting, and Balancing" and in this Section.

B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.

   1. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.
   2. After testing and balancing, install test ports and duct access doors that comply with requirements in Section 233300 "Air Duct Accessories."

3. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Section 230713 "Duct Insulation," Section 230716 "HVAC Equipment Insulation," and Section 230719 "HVAC Piping Insulation."

C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings. D. Take and report testing and balancing measurements in inch-pound (IP) units.

3.5 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Cross-check the summation of required outlet volumes with required fan volumes.

B. Prepare schematic diagrams of systems' "as-built" duct layouts.

C. For variable-air-volume systems, develop a plan to simulate diversity.

D. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.

E. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.

F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

G. Verify that motor starters are equipped with properly sized thermal protection.

H. Check dampers for proper position to achieve desired airflow path.

I. Check for airflow blockages.

J. Check condensate drains for proper connections and functioning.

K. Check for proper sealing of air-handling-unit components.

L. Verify that air duct system is sealed as specified in Section 233113 "Metal Ducts."

3.6 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.

1. Measure total airflow.

a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
b. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.
c. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
d. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.

2. Measure fan static pressures as follows:

a. Measure static pressure directly at the fan outlet or through the flexible connection.
b. Measure static pressure directly at the fan inlet or through the flexible connection.
c. Measure static pressure across each component that makes up the airhandling system.
d. Report artificial loading of filters at the time static pressures are measured.

3. Review Record Documents to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
4. Obtain approval from Architect, Construction Manager and commissioning authority for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in HVAC Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handlingunit performance.
5. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload occurs. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.

B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows.

1. Measure airflow of submain and branch ducts.
2. Adjust submain and branch duct volume dampers for specified airflow.
3. Re-measure each submain and branch duct after all have been adjusted.

C. Adjust air inlets and outlets for each space to indicated airflows.

1. Set airflow patterns of adjustable outlets for proper distribution without drafts.
2. Measure inlets and outlets airflow.
3. Adjust each inlet and outlet for specified airflow.
4. Re-measure each inlet and outlet after they have been adjusted. D. Verify final

system conditions.

1. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to design if necessary.
2. Re-measure and confirm that total airflow is within design.
3. Re-measure all final fan operating data, rpms, volts, amps, and static profile.
4. Mark all final settings.
5. Test system in economizer mode. Verify proper operation and adjust if necessary.
6. Measure and record all operating data.
7. Record final fan-performance data.

3.7 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

A. Adjust the variable-air-volume systems as follows:

1. Verify that the system static pressure sensor is located two-thirds of the distance down the duct from the fan discharge.
2. Verify that the system is under static pressure control.
3. Select the terminal unit that is most critical to the supply-fan airflow. Measure inlet static pressure, and adjust system static pressure control set point so the entering static pressure for the critical terminal unit is not less than the sum of the terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
4. Calibrate and balance each terminal unit for maximum and minimum design airflow as follows:

   a. Adjust controls so that terminal is calling for maximum airflow. Some controllers require starting with minimum airflow. Verify calibration procedure for specific project.
   b. Measure airflow and adjust calibration factor as required for design maximum airflow. Record calibration factor.
   c. When maximum airflow is correct, balance the air outlets downstream from terminal units.
   d. Adjust controls so that terminal is calling for minimum airflow.
   e. Measure airflow and adjust calibration factor as required for design minimum airflow. Record calibration factor. If no minimum calibration is available, note any deviation from design airflow.
   f. When in full cooling or full heating, ensure that there is no mixing of hot-deck and cold-deck airstreams unless so designed.
   g. On constant volume terminals, in critical areas where room pressure is to be maintained, verify that the airflow remains constant over the full range of full cooling to full heating. Note any deviation from design airflow or room pressure.

5. After terminals have been calibrated and balanced, test and adjust system for total airflow. Adjust fans to deliver total design airflows within the maximum allowable fan speed listed by fan manufacturer.

a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
b. Set terminals for maximum airflow. If system design includes diversity, adjust terminals for maximum and minimum airflow so that connected total matches fan selection and simulates actual load in the building.
c. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.
d. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
e. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.

6. Measure fan static pressures as follows:

a. Measure static pressure directly at the fan outlet or through the flexible connection.
b. Measure static pressure directly at the fan inlet or through the flexible connection.
c. Measure static pressure across each component that makes up the airhandling system.
d. Report any artificial loading of filters at the time static pressures are measured.

7. Set final return and outside airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.

a. Balance the return-air ducts and inlets the same as described for constant-volume air systems.
b. Verify that terminal units are meeting design airflow under system maximum flow.

8. Re-measure the inlet static pressure at the most critical terminal unit and adjust the system static pressure set point to the most energy-efficient set point to maintain the optimum system static pressure. Record set point and give to controls contractor.
9. Verify final system conditions as follows:

a. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to match design if necessary.
b. Re-measure and confirm that total airflow is within design.
c. Re-measure final fan operating data, rpms, volts, amps, and static profile.
d. Mark final settings.
e. Test system in economizer mode. Verify proper operation and adjust if necessary. Measure and record all operating data.
f. Verify tracking between supply and return fans.

3.8 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

A. Prepare test reports for pumps, coils, and heat exchangers. Obtain approved submittals and manufacturer-recommended testing procedures. Crosscheck the summation of required coil and heat exchanger flow rates with pump design flow rate.

B. Prepare schematic diagrams of systems' "as-built" piping layouts.

C. In addition to requirements in "Preparation" Article, prepare hydronic systems for testing and balancing as follows:

1. Check liquid level in expansion tank.
2. Check highest vent for adequate pressure.
3. Check flow-control valves for proper position.
4. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
5. Verify that motor starters are equipped with properly sized thermal protection.
6. Check that air has been purged from the system.

3.9 PROCEDURES FOR CONSTANT-FLOW HYDRONIC SYSTEMS

A. Adjust pumps to deliver total design GPM.

1. Measure total water flow.

   a. Position valves for full flow through coils.
   b. Measure flow by main flow meter, if installed.
   c. If main flow meter is not installed, determine flow by pump TDH or exchanger pressure drop.

2. Measure pump TDH as follows:

   a. Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
   b. Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
   c. Convert pressure to head and correct for differences in gage heights.
   d. Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow, and verify that the pump has the intended impeller size.
   e. With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved.

3. Monitor motor performance during procedures and do not operate motor in an overloaded condition.

B. Adjust flow-measuring devices installed in mains and branches to design water flows.

1. Measure flow in main and branch pipes.
2. Adjust main and branch balance valves for design flow.

3. Re-measure each main and branch after all have been adjusted.

C. Adjust flow-measuring devices installed at terminals for each space to design water flows.

1. Measure flow at terminals.
2. Adjust each terminal to design flow.
3. Re-measure each terminal after it is adjusted.
4. Position control valves to bypass the coil, and adjust the bypass valve to maintain design flow.
5. Perform temperature tests after flows have been balanced. D. For systems with

pressure-independent valves at terminals:

1. Measure differential pressure and verify that it is within manufacturer's specified range.
2. Perform temperature tests after flows have been verified.

E. For systems without pressure-independent valves or flow-measuring devices at terminals:

1. Measure and balance coils by either coil pressure drop or temperature method.
2. If balanced by coil pressure drop, perform temperature tests after flows have been verified.

F. Verify final system conditions as follows:

1. Re-measure and confirm that total water flow is within design.
2. Re-measure final pumps' operating data, TDH, volts, amps, and static profile.
3. Mark final settings.

G. Verify that memory stops have been set.

3.10 PROCEDURES FOR VARIABLE-FLOW HYDRONIC SYSTEMS

A. Balance systems with automatic two- and three-way control valves by setting systems at maximum flow through heat-exchange terminals, and proceed as specified above for hydronic systems.

B. Adjust the variable-flow hydronic system as follows:

1. Verify that the differential-pressure sensor is located as indicated.
2. Determine whether there is diversity in the system. C. For

systems with no diversity:

1. Adjust pumps to deliver total design GPM.

a. Measure total water flow.

1) Position valves for full flow through coils.
2) Measure flow by main flow meter, if installed.
3) If main flow meter is not installed, determine flow by pump TDH or exchanger pressure drop.

b. Measure pump TDH as follows:

1) Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
2) Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
3) Convert pressure to head and correct for differences in gage heights.
4) Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
5) With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved.

c. Monitor motor performance during procedures and do not operate motor in an overloaded condition.

2. Adjust flow-measuring devices installed in mains and branches to design water flows.

a. Measure flow in main and branch pipes.
b. Adjust main and branch balance valves for design flow.
c. Re-measure each main and branch after all have been adjusted.

3. Adjust flow-measuring devices installed at terminals for each space to design water flows.

a. Measure flow at terminals.
b. Adjust each terminal to design flow.
c. Re-measure each terminal after it is adjusted.
d. Position control valves to bypass the coil and adjust the bypass valve to maintain design flow.
e. Perform temperature tests after flows have been balanced.

4. For systems with pressure-independent valves at terminals:

a. Measure differential pressure and verify that it is within manufacturer's specified range.
b. Perform temperature tests after flows have been verified.

5. For systems without pressure-independent valves or flow-measuring devices at terminals:

a. Measure and balance coils by either coil pressure drop or temperature method.
b. If balanced by coil pressure drop, perform temperature tests after flows have been verified.

6. Prior to verifying final system conditions, determine the system differentialpressure set point.
7. If the pump discharge valve was used to set total system flow with variablefrequency controller at 60 Hz, at completion open discharge valve 100 percent and allow variable-frequency controller to control system differentialpressure set point. Record pump data under both conditions.
8. Mark final settings and verify that all memory stops have been set.
9. Verify final system conditions as follows:

a. Re-measure and confirm that total water flow is within design.
b. Re-measure final pumps' operating data, TDH, volts, amps, and static profile.
c. Mark final settings.

10. Verify that memory stops have been set. D. For systems with diversity:

1. Determine diversity factor.
2. Simulate system diversity by closing required number of control valves, as approved by the design engineer.
3. Adjust pumps to deliver total design gpm.

a. Measure total water flow.

1) Position valves for full flow through coils.
2) Measure flow by main flow meter, if installed.
3) If main flow meter is not installed, determine flow by pump TDH or exchanger pressure drop.

b. Measure pump TDH as follows:

1) Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
2) Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
3) Convert pressure to head and correct for differences in gage heights.
4) Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
5) With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved.

c. Monitor motor performance during procedures and do not operate motor in an overloaded condition.

4. Adjust flow-measuring devices installed in mains and branches to design water flows.

    a. Measure flow in main and branch pipes.
    b. Adjust main and branch balance valves for design flow.
    c. Re-measure each main and branch after all have been adjusted.

5. Adjust flow-measuring devices installed at terminals for each space to design water flows.

    a. Measure flow at terminals.
    b. Adjust each terminal to design flow.
    c. Re-measure each terminal after it is adjusted.
    d. Position control valves to bypass the coil, and adjust the bypass valve to maintain design flow.
    e. Perform temperature tests after flows have been balanced.

6. For systems with pressure-independent valves at terminals:

    a. Measure differential pressure, and verify that it is within manufacturer's specified range.
    b. Perform temperature tests after flows have been verified.

7. For systems without pressure-independent valves or flow-measuring devices at terminals:

    a. Measure and balance coils by either coil pressure drop or temperature method.
    b. If balanced by coil pressure drop, perform temperature tests after flows have been verified.

8. Open control valves that were shut. Close a sufficient number of control valves that were previously open to maintain diversity, and balance terminals that were just opened.
9. Prior to verifying final system conditions, determine system differentialpressure set point.
10. If the pump discharge valve was used to set total system flow with variablefrequency controller at 60 Hz, at completion open discharge valve 100 percent and allow variable-frequency controller to control system differentialpressure set point. Record pump data under both conditions.
11. Mark final settings and verify that memory stops have been set.
12. Verify final system conditions as follows:

    a. Re-measure and confirm that total water flow is within design.
    b. Re-measure final pumps' operating data, TDH, volts, amps, and static profile.
    c. Mark final settings.

13. Verify that memory stops have been set.

3.11 PROCEDURES FOR STEAM SYSTEMS

A. Measure and record upstream and downstream pressure of each piece of equipment.
B. Measure and record upstream and downstream steam pressure of pressurereducing valves.

C. Check settings and operation of automatic temperature-control valves, selfcontained control valves, and pressure-reducing valves. Record final settings. D. Check settings and operation of each safety valve. Record settings.

E. Verify the operation of each steam trap.

3.12 PROCEDURES FOR MOTORS

A. Motors 1/2 HP and Larger: Test at final balanced conditions and record the following data:

1. Manufacturer's name, model number, and serial number.
2. Motor horsepower rating.
3. Motor rpm.
4. Phase and hertz.
5. Nameplate and measured voltage, each phase.
6. Nameplate and measured amperage, each phase.
7. Starter size and thermal-protection-element rating.
8. Service factor and frame size.

B. Motors Driven by Variable-Frequency Controllers: Test manual bypass of controller to prove proper operation.

3.13 PROCEDURES FOR CONDENSING UNITS

A. Verify proper rotation of fans.

B. Measure entering- and leaving-air temperatures.

C. Record fan and motor operating data.

3.14 PROCEDURES FOR BOILERS

A. Hydronic Boilers:

1. Measure and record entering- and leaving-water temperatures.
2. Measure and record water flow.
3. Record relief valve pressure setting. B. Steam Boilers:

1. Measure and record entering-water temperature.

2. Measure and record feed water flow.
3. Measure and record leaving-steam pressure and temperature.
4. Record relief valve pressure setting.

3.15 PROCEDURES FOR HEAT-TRANSFER COILS

A. Measure, adjust, and record the following data for each water coil:

1. Entering- and leaving-water temperature.
2. Water flow rate.
3. Water pressure drop for major (more than 20 GPM) equipment coils, excluding unitary equipment such as reheat coils, unit heaters, and fan-coil units.
4. Dry-bulb temperature of entering and leaving air.
5. Wet-bulb temperature of entering and leaving air for cooling coils.
6. Airflow.

B. Measure, adjust, and record the following data for each electric heating coil:

1. Nameplate data.
2. Airflow.
3. Entering- and leaving-air temperature at full load.
4. Voltage and amperage input of each phase at full load.
5. Calculated kilowatt at full load.
6. Fuse or circuit-breaker rating for overload protection.

C. Measure, adjust, and record the following data for each steam coil:

1. Dry-bulb temperature of entering and leaving air.
2. Airflow.
3. Inlet steam pressure.

D. Measure, adjust, and record the following data for each refrigerant coil:

1. Dry-bulb temperature of entering and leaving air.
2. Wet-bulb temperature of entering and leaving air.
3. Airflow.

3.16 SOUND TESTS

A. After the systems are balanced and construction is Substantially Complete, measure and record sound levels at **10** locations as designated by the Architect. B. Instrumentation:

1. The sound-testing meter shall be a portable, general-purpose testing meter consisting of a microphone, processing unit, and readout.
2. The sound-testing meter shall be capable of showing fluctuations at minimum and maximum levels, and measuring the equivalent continuous sound pressure level (LEQ).

3. The sound-testing meter must be capable of using 1/3 octave band filters to measure mid-frequencies from 31.5 Hz to 8000 Hz.
4. The accuracy of the sound-testing meter shall be plus or minus one decibel.

C. Test Procedures:

1. Perform test at quietest background noise period. Note cause of unpreventable sound that affects test outcome.
2. Equipment should be operating at design values.
3. Calibrate the sound-testing meter prior to taking measurements.
4. Use a microphone suitable for the type of noise levels measured that is compatible with meter. Provide a windshield for outside or in-duct measurements.
5. Record a set of background measurements in dBA and sound pressure levels in the eight un-weighted octave bands 63 Hz to 8000 Hz (NC)] with the equipment off.
6. Take sound readings in dBA and sound pressure levels in the eight unweighted octave bands 63 Hz to 8000 Hz (NC) with the equipment operating.
7. Take readings no closer than 36 inches from a wall or from the operating equipment and approximately 60 inches from the floor, with the meter held or mounted on a tripod.
8. For outdoor measurements, move sound-testing meter slowly and scan area that has the most exposure to noise source being tested. Use A-weighted scale for this type of reading. D. Reporting:

1. Report shall record the following:

   a. Location.
   b. System tested.
   c. dBA reading.
   d. Sound pressure level in each octave band with equipment on and off.

2. Plot sound pressure levels on NC worksheet with equipment on and off.

3.17 VIBRATION TESTS

A. After systems are balanced and construction is Substantially Complete, measure and record vibration levels on equipment having motor horsepower equal to or greater than **15**.

B. Instrumentation:

1. Use portable, battery-operated, and microprocessor-controlled vibration meter with or without a built-in printer.
2. The meter shall automatically identify engineering units, filter bandwidth, amplitude, and frequency scale values.

3. The meter shall be able to measure machine vibration displacement in mils of deflection, velocity in inches per second, and acceleration in inches per second squared.
4. Verify calibration date is current for vibration meter before taking readings. C.

Test Procedures:

1. To ensure accurate readings, verify that accelerometer has a clean, flat surface and is mounted properly.
2. With the unit running, set up vibration meter in a safe, secure location. Connect transducer to meter with proper cables. Hold magnetic tip of transducer on top of the bearing, and measure unit in mils of deflection. Record measurement, then move transducer to the side of the bearing and record in mils of deflection. Record an axial reading in mils of deflection by holding nonmagnetic, pointed transducer tip on end of shaft.
3. Change vibration meter to velocity (inches per second) measurements. Repeat and record above measurements.
4. Record CPM or rpm.
5. Read each bearing on motor, fan, and pump as required. Track and record vibration levels from rotating component through casing to base. D.

Reporting:

1. Report shall record location and the system tested.
2. Include horizontal-vertical-axial measurements for tests.
3. Verify that vibration limits follow Specifications, or, if not specified, follow the General Machinery Vibration Severity Chart or Vibration Acceleration General Severity Chart from the AABC National Standards. Acceptable levels of vibration are normally "smooth" to "good."
4. Include in report General Machinery Vibration Severity Chart, with conditions plotted.

3.18 DUCT LEAKAGE TESTS

A. Witness the duct pressure testing performed by Installer.

B. Verify that proper test methods are used and that leakage rates are within specified tolerances.

C. Report deficiencies observed.

3.19 CONTROLS VERIFICATION

A. In conjunction with system balancing, perform the following:

1. Verify temperature control system is operating within the design limitations.
2. Confirm that the sequences of operation are in compliance with Contract Documents.

3. Verify that controllers are calibrated and function as intended.
4. Verify that controller set points are as indicated.
5. Verify the operation of lockout or interlock systems.
6. Verify the operation of valve and damper actuators.
7. Verify that controlled devices are properly installed and connected to correct controller.
8. Verify that controlled devices travel freely and are in position indicated by controller: open, closed, or modulating.
9. Verify location and installation of sensors to ensure that they sense only intended temperature, humidity, or pressure.

B. Reporting: Include a summary of verifications performed, remaining deficiencies, and variations from indicated conditions.

3.20 PROCEDURES FOR TESTING, ADJUSTING, AND BALANCING EXISTING SYSTEMS

A. Perform a preconstruction inspection of existing equipment that is to remain and be reused.

1. Measure and record the operating speed, airflow, and static pressure of each fan.
2. Measure motor voltage and amperage. Compare the values to motor nameplate information.
3. Check the refrigerant charge.
4. Check the condition of filters.
5. Check the condition of coils.
6. Check the operation of the drain pan and condensate-drain trap.
7. Check bearings and other lubricated parts for proper lubrication.
8. Report on the operating condition of the equipment and the results of the measurements taken. Report deficiencies.

B. Before performing testing and balancing of existing systems, inspect existing equipment that is to remain and be reused to verify that existing equipment has been cleaned and refurbished. Verify the following:

1. New filters are installed.
2. Coils are clean and fins combed.
3. Drain pans are clean.
4. Fans are clean.
5. Bearings and other parts are properly lubricated.
6. Deficiencies noted in the preconstruction report are corrected.

C. Perform testing and balancing of existing systems to the extent that existing systems are affected by the renovation work.

1. Compare the indicated airflow of the renovated work to the measured fan airflows, and determine the new fan speed and the face velocity of filters and coils.
2. Verify that the indicated airflows of the renovated work result in filter and coil face velocities and fan speeds that are within the acceptable limits defined by equipment manufacturer.
3. If calculations increase or decrease the airflow rates and water flow rates by more than 5 percent, make equipment adjustments to achieve the calculated rates. If increase or decrease is 5 percent or less, equipment adjustments are not required.
4. Balance each air outlet.

3.21 TOLERANCES

A. Set HVAC system's airflow rates and water flow rates within the following tolerances:

1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 10 percent.
2. Air Outlets and Inlets: Plus or minus 10 percent.
3. Heating-Water Flow Rate: Plus or minus 10 percent.
4. Cooling-Water Flow Rate: Plus or minus 10 percent.

B. Maintaining pressure relationships as designed shall have priority over the tolerances specified above.

3.22 PROGRESS REPORTING

A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for systems balancing devices. Recommend changes and additions to systems balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.

B. Status Reports: Prepare **biweekly** progress reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

3.23 FINAL REPORT

A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.

1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
2. Include a list of instruments used for procedures, along with proof of calibration.

3. Certify validity and accuracy of field data.

B. Final Report Contents: In addition to certified field-report data, include the following:

1. Pump curves.
2. Fan curves.
3. Manufacturers' test data.
4. Field test reports prepared by system and equipment installers.
5. Other information relative to equipment performance; do not include Shop Drawings and Product Data.

C. General Report Data: In addition to form titles and entries, include the following data:

1. Title page.
2. Name and address of the TAB specialist.
3. Project name.
4. Project location.
5. Architect's name and address. 6. Engineer's name and address.
7. Contractor's name and address.
8. Report date.
9. Signature of TAB supervisor who certifies the report.
10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
11. Summary of contents including the following:

    a. Indicated versus final performance.
    b. Notable characteristics of systems.
    c. Description of system operation sequence if it varies from the Contract Documents.

12. Nomenclature sheets for each item of equipment.
13. Data for terminal units, including manufacturer's name, type, size, and fittings.
14. Notes to explain why certain final data in the body of reports vary from indicated values.
15. Test conditions for fans and pump performance forms including the following:

    a. Settings for outdoor-, return-, and exhaust-air dampers.
    b. Conditions of filters.
    c. Cooling coil, wet- and dry-bulb conditions.
    d. Face and bypass damper settings at coils.
    e. Fan drive settings including settings and percentage of maximum pitch diameter.
    f. Inlet vane settings for variable-air-volume systems.
    g. Settings for supply-air, static-pressure controller.
    h. Other system operating conditions that affect performance.

D. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:

1. Quantities of outdoor, supply, return, and exhaust airflows.

2. Water and steam flow rates.
3. Duct, outlet, and inlet sizes.
4. Pipe and valve sizes and locations.
5. Terminal units.
6. Balancing stations.
7. Position of balancing devices.

E. Air-Handling-Unit Test Reports: For air-handling units with coils, include the following:

1. Unit Data:

   a. Unit identification.
   b. Location.
   c. Make and type.
   d. Model number and unit size.
   e. Manufacturer's serial number.
   f. Unit arrangement and class.
   g. Discharge arrangement.
   h. Sheave make, size in inches, and bore.
   i. Center-to-center dimensions of sheave and amount of adjustments in inches.
   j. Number, make, and size of belts.
   k. Number, type, and size of filters.

2. Motor Data:

   a. Motor make, and frame type and size.
   b. Horsepower and rpm.
   c. Volts, phase, and hertz.
   d. Full-load amperage and service factor.
   e. Sheave make, size in inches, and bore.
   f. Center-to-center dimensions of sheave and amount of adjustments in inches.

3. Test Data (Indicated and Actual Values):

   a. Total airflow rate in cfm.
   b. Total system static pressure in inches wg.
   c. Fan rpm.
   d. Discharge static pressure in inches wg.
   e. Filter static-pressure differential in inches wg.
   f. Preheat-coil static-pressure differential in inches.
   g. Cooling-coil static-pressure differential in inches.
   h. Heating-coil static-pressure differential in inches wg.
   i. Outdoor airflow in cfm.
   j. Return airflow in cfm.
   k. Outdoor-air damper position.
   l. Return-air damper position.

m. Vortex damper position. F. Apparatus-Coil Test Reports:

1. Coil Data:

   a. System identification.
   b. Location.
   c. Coil type.
   d. Number of rows.
   e. Fin spacing in fins per inch o.c.
   f. Make and model number.
   g. Face area in sq. ft.
   h. Tube size in NPS.
   i. Tube and fin materials.
   j. Circuiting arrangement.

2. Test Data (Indicated and Actual Values):

   a. Airflow rate in cfm.
   b. Average face velocity in fpm.
   c. Air pressure drop in inches wg.
   d. Outdoor-air, wet- and dry-bulb temperatures in deg F.
   e. Return-air, wet- and dry-bulb temperatures in deg F.
   f. Entering-air, wet- and dry-bulb temperatures in deg F.
   g. Leaving-air, wet- and dry-bulb temperatures in deg F.
   h. Water flow rate in gpm.
   i. Water pressure differential in feet of head or psig.
   j. Entering-water temperature in deg F.
   k. Leaving-water temperature in deg F.
   l. Refrigerant expansion valve and refrigerant types.
   m. Refrigerant suction pressure in psig.
   n. Refrigerant suction temperature in deg F.
   o. Inlet steam pressure in psig.

G. Fan Test Reports: For supply, return, and exhaust fans, include the following:

1. Fan Data:

   a. System identification.
   b. Location.
   c. Make and type.
   d. Model number and size.
   e. Manufacturer's serial number.
   f. Arrangement and class.
   g. Sheave make, size in inches, and bore.
   h. Center-to-center dimensions of sheave and amount of adjustments in inches.

2. Motor Data:

a. Motor make, and frame type and size.
b. Horsepower and rpm.
c. Volts, phase, and hertz.
d. Full-load amperage and service factor.
e. Sheave make, size in inches, and bore.
f. Center-to-center dimensions of sheave, and amount of adjustments in inches.
g. Number, make, and size of belts.

3. Test Data (Indicated and Actual Values):

a. Total airflow rate in cfm.
b. Total system static pressure in inches wg.
c. Fan rpm.
d. Discharge static pressure in inches wg.
e. Suction static pressure in inches wg.

H. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:

1. Report Data:

a. System and air-handling-unit number.
b. Location and zone.
c. Traverse air temperature in deg F.
d. Duct static pressure in inches wg.
e. Duct size in inches.
f. Duct area in sq. ft.
g. Indicated airflow rate in cfm.
h. Indicated velocity in fpm.
i. Actual airflow rate in cfm
j. Actual average velocity in fpm.
k. Barometric pressure in psig. I. Air-Terminal-Device Reports:

1. Unit Data:

a. System and air-handling unit identification.
b. Location and zone.
c. Apparatus used for test.
d. Area served.
e. Make.
f. Number from system diagram.
g. Type and model number.
h. Size.
i. Effective area in sq. ft.

2. Test Data (Indicated and Actual Values):

a. Airflow rate in cfm.

b. Air velocity in fpm.
c. Preliminary airflow rate as needed in cfm.
d. Preliminary velocity as needed in fpm.
e. Final airflow rate in cfm.
f. Final velocity in fpm.
g. Space temperature in deg F.

J. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:

1. Unit Data:
   a. System and air-handling-unit identification.
   b. Location and zone.
   c. Room or riser served.
   d. Coil make and size.
   e. Flowmeter type.

2. Test Data (Indicated and Actual Values):

   a. Airflow rate in cfm.
   b. Entering-water temperature in deg F.
   c. Leaving-water temperature in deg F.
   d. Water pressure drop in feet of head or psig.
   e. Entering-air temperature in deg F.
   f. Leaving-air temperature in deg F.

K. Pump Test Reports: Calculate impeller size by plotting the shutoff head on pump curves and include the following:

1. Unit Data:

   a. Unit identification.
   b. Location.
   c. Service.
   d. Make and size.
   e. Model number and serial number.
   f. Water flow rate in gpm.
   g. Water pressure differential in feet of head or psig.
   h. Required net positive suction head in feet of head or psig.
   i. Pump rpm.
   j. Impeller diameter in inches.
   k. Motor make and frame size.
   l. Motor horsepower and rpm.
   m. Voltage at each connection.
   n. Amperage for each phase.
   o. Full-load amperage and service factor.
   p. Seal type.

2. Test Data (Indicated and Actual Values):

a. Static head in feet of head or psig.
b. Pump shutoff pressure in feet of head or psig.
c. Actual impeller size in inches.
d. Full-open flow rate in gpm.
e. Full-open pressure in feet of head or psig.
f. Final discharge pressure in feet of head or psig.
g. Final suction pressure in feet of head or psig.
h. Final total pressure in feet of head or psig.
i. Final water flow rate in gpm.
j. Voltage at each connection.
k. Amperage for each phase.

L. Instrument Calibration Reports:

1. Report Data:

a. Instrument type and make.
b. Serial number.
c. Application.
d. Dates of use.
e. Dates of calibration.

3.24 VERIFICATION OF TAB REPORT

A. The TAB specialist's test and balance engineer shall conduct the inspection in the presence of Architect, Owner, Construction Manager and commissioning authority.

B. Architect, Owner, Construction Manager and commissioning authority shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8hour business day.

C. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."

D. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected. E. If TAB work fails, proceed as follows:

1. TAB specialists shall recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection.
2. If the second final inspection also fails, Owner may contract the services of another TAB specialist to complete TAB work according to the Contract Documents and deduct the cost of the services from the original TAB specialist's final payment.

3. If the second verification also fails, [**Owner**] [**design professional**] [**Architect**] may contact AABC Headquarters regarding the AABC National Performance Guaranty.

F. Prepare test and inspection reports.

3.25 ADDITIONAL TESTS

A. Within 90 days of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

END OF SECTION

SECTION 230713
DUCT INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes insulating the following duct services:
   1. Indoor, concealed supply and outdoor air.
   2. Indoor, exposed supply and outdoor air.
   3. Indoor, concealed return located in unconditioned space.
   4. Indoor, exposed return located in unconditioned space.
   5. Indoor, concealed, Type I, commercial, kitchen hood exhaust.
   6. Indoor, exposed, Type I, commercial, kitchen hood exhaust.
   7. Indoor, concealed oven and warewash exhaust.
   8. Indoor, exposed oven and warewash exhaust.
   9. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
   10. Indoor, exposed exhaust between isolation damper and penetration of building exterior.
   11. Outdoor, concealed supply and return.
   12. Outdoor, exposed supply and return.

B. Related Sections:
   1. Section 230716 "HVAC Equipment Insulation."
   2. Section 230719 "HVAC Piping Insulation."
   3. Section 233113 "Metal Ducts" for duct liners.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory- and field-applied if any).

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
2. Detail insulation application at elbows, fittings, dampers, specialties and flanges for each type of insulation.
3. Detail application of field-applied jackets.
4. Detail application at linkages of control devices.

C. Samples: For each type of insulation and jacket indicated. Identify each Sample, describing product and intended use. Sample sizes are as follows:
   1. Sheet Form Insulation Materials: 12 inches square.
   2. Sheet Jacket Materials: 12 inches square.
   3. Manufacturer's Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

B. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed. C. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.
   1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smokedeveloped index of 50 or less.
   2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smokedeveloped index of 150 or less.

C. Mockups: Before installing insulation, build mockups for each type of insulation and finish listed below to demonstrate quality of insulation application and finishes. Build mockups in the location indicated or, if not indicated, as directed by Architect.

Use materials indicated for the completed Work.

1. Ductwork Mockups:
    a. One 10-foot section each of rectangular and round straight duct.
    b. One each of a 90-degree mitered round and rectangular elbow, and one each of a 90-degree radius round and rectangular elbow.
    c. One rectangular branch takeoff and one round branch takeoff from a rectangular duct. One round tee fitting.
    d. One rectangular and round transition fitting.
    e. Four support hangers for round and rectangular ductwork.
    f. Each type of damper and specialty.
2. For each mockup, fabricate cutaway sections to allow observation of application details for insulation materials, adhesives, mastics, attachments, and jackets.
3. Notify Architect seven days in advance of dates and times when mockups will be constructed.
4. Obtain Architect's approval of mockups before starting insulation application.
5. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
6. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
7. Demolish and remove mockups when directed.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.7 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

B. Coordinate clearance requirements with duct Installer for duct insulation application. Before preparing ductwork Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

C. Coordinate installation and testing of heat tracing.

1.8 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Comply with requirements in "Duct Insulation Schedule, General," "Indoor Duct and Plenum Insulation Schedule," and "Aboveground, Outdoor Duct and Plenum Insulation Schedule" articles for where insulating materials shall be applied. B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

A. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type II for sheet materials. For indoor applications insulation meet ASTM E84 Flame Spread and Smoke Developed ratings of 25/50 for thickness required. For duct applications, color shall be selected by the architect from manufacturer standard color options.

PART 3 - See Editing Instruction No. 1 in the Evaluations for cautions about naming manufacturers and products. See Section 016000 "Product Requirements."

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
    a. Aeroflex USA, Inc.; Aerocel.
    b. Armacell LLC; AP Armaflex and Armaflex FS.
    c. K-Flex USA; Insul-Sheet and Insul-Tube.

B. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type I, Type II with factory-applied vinyl jacket, Type III with factory-applied FSK jacket, Type III with factory-applied FSP jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
   a. Johns Manville; a Berkshire Hathaway company.
   b. Knauf Insulation.
   c. Manson Insulation Inc.
   d. Owens Corning.

C. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB. For duct and plenum applications, provide insulation without factory-applied jacket, with factory-applied ASJ, with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
1. For duct and plenum applications, provide insulation with factory-applied FSK jacket.
2. Provide insulation with factory-applied ASJ for equipment. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
3. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
   a. CertainTeed Corp.; Commercial Board.
   b. Fibrex Insulations Inc.; FBX.
   c. Johns Manville; 800 Series Spin-Glas.
   d. Knauf Insulation; Earthwool Insulation Board with ECOSE Technology
   e. Manson Insulation Inc.; AK Board.
   f. Owens Corning; Fiberglas 700 Series.

A. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied ASJ, FSK jacket complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb/cu. ft. or more. Thermal conductivity (k-value) at 100 deg F is 0.29 Btu x in./h x sq. ft. x deg F or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

B.
1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
   a. CertainTeed Corp.; CrimpWrap.
   b. Johns Manville; MicroFlex.
   c. Knauf Insulation; Earthwool Pipe & Tank Insulation with ECOSE Technology.
   d. Knauf Insulation: Kwik-Flex Pipe & Tank Insulation.
   e. Manson Insulation Inc.; AK Flex.
   f. Owens Corning; Fiberglas Pipe and Tank Insulation.

3.2 FIRE-RATED INSULATION SYSTEMS

A. Fire-Rated Board: Structural-grade, press-molded, xonolite calcium silicate, fireproofing board suitable for operating temperatures up to 1700 deg F. Comply with ASTM C 656, Type II, Grade 6. Tested and certified to provide a 1 or 2-hour fire rating by an NRTL acceptable to authorities having jurisdiction.
   a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
      1) Johns Manville; Super Firetemp M.

B. Fire-Rated Blanket: High-temperature, flexible, blanket insulation with FSK jacket that is tested and certified to provide a 1 or 2-hour fire rating by an NRTL acceptable to authorities having jurisdiction.
   a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
      1) CertainTeed Corp.; FlameChek.
      2) Johns Manville; Firetemp Wrap.
      3) Nelson Fire Stop Products; Nelson FSB Flameshield Blanket.
      4) Thermal Ceramics; FireMaster Duct Wrap.
      5) 3M; Fire Barrier Wrap Products. 6) Unifrax Corporation; FyreWrap.

3.3 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

B. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.
   1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
      a. Aeroflex USA, Inc.; Aeroseal Low VOC.
      b. Armacell LLC; Armaflex 520BLV Adhesive.
      c. K-Flex USA; 720-LVOC Contact Adhesive.
      d. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-75.

C. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
   1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
      a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-127.
      b. Eagle Bridges - Marathon Industries; 225.
      c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-60/85-70.

D. ASJ Adhesive, and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
   1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
      a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-82.
      b. Eagle Bridges - Marathon Industries; 225.
      c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-50.
      d. Mon-Eco Industries, Inc.; 22-25.

3.4 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.
   1. VOC Content: 300 g/L or less.
   2. Low-Emitting Materials: Mastic coatings shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." The building concentration of formaldehyde shall not exceed half of the indoor recommended exposure limit, 9 mcg/cu. m or 7 ppb, whichever is less, and that of acetaldehyde shall not exceed 9 mcg/cu. m.

B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below ambient services.
   1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
      a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-80/30-90.
      b. Vimasco Corporation; 749.
      c.
   2. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm at 43mil dry film thickness.
   3. Service Temperature Range: Minus 20 to plus 180 deg F.
   4. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
   5. Color: White.

C. Vapor-Barrier Mastic: Solvent based; suitable for indoor use on below ambient services.
   1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
      a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Encacel.

b. Eagle Bridges - Marathon Industries; 570.
c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 60-95/60-96.
d.

2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 35-mil dry film thickness.
3. Service Temperature Range: 0 to 180 deg F.
4. Solids Content: ASTM D 1644, 44 percent by volume and 62 percent by weight.
5. Color: White.

D. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below ambient services.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Encacel.
   b. Eagle Bridges - Marathon Industries; 570.
   c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 60-95/60-96.
   d.
2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 35-mil dry film thickness.
3. Service Temperature Range: 0 to 180 deg F.
4. Solids Content: ASTM D 1644, 44 percent by volume and 62 percent by weight.
5. Color: White.

E. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-10.
   b. Eagle Bridges - Marathon Industries; 550.
   c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 46-50.
   d. Mon-Eco Industries, Inc.; 55-50.
   e. Vimasco Corporation; WC-1/WC-5.
   f.
2. Water-Vapor Permeance: ASTM F 1249, 1.8 perms at 0.0625-inch dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F.
4. Solids Content: 60 percent by volume and 66 percent by weight.
5. Color: White.

3.5 LAGGING ADHESIVES

A. Description: Comply with MIL-A-3316C, Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.
   1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
      a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-50 AHV2.
      b. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-36.
      c. Vimasco Corporation; 713 and 714.
      d.
   2. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over pipe insulation.
   3. Adhesives shall have a VOC content of 250 g/L or less.
   4. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." The building concentration of formaldehyde shall not exceed half of the indoor recommended exposure limit, 9 mcg/cu. m or 7 ppb, whichever is less, and that of acetaldehyde shall not exceed 9 mcg/cu. m.
   5. Service Temperature Range: 0 to plus 180 deg F.
   6. Color: White.

3.6 SEALANTS

A. FSK and Metal Jacket Flashing Sealants:
   1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
      a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
      b. Eagle Bridges - Marathon Industries; 405.
      c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 95-44.
      d. Mon-Eco Industries, Inc.; 44-05.
      e.
   2. Materials shall be compatible with insulation materials, jackets, and substrates.
   3. Fire- and water-resistant, flexible, elastomeric sealant.
   4. Service Temperature Range: Minus 40 to plus 250 deg F.
   5. Color: Aluminum.
   6. Sealant shall have a VOC content of 420 g/L or less.
   7. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." The building concentration of formaldehyde shall

not exceed half of the indoor recommended exposure limit, 9 mcg/cu. m or 7 ppb, whichever is less, and that of acetaldehyde shall not exceed 9 mcg/cu. m.

B. ASJ Flashing Sealants, and Vinyl and PVC Jacket Flashing Sealants:
1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F.
5. Color: White.

3.7 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.
4. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C 1136, Type II.

3.8 FIELD-APPLIED FABRIC-REINFORCING MESH

A. Woven Glass-Fiber Fabric: Approximately 6 oz./sq. yd. with a thread count of 5 strands by 5 strands/sq. in. for covering ducts.
1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Chil-Glas No. 5.

B. Woven Polyester Fabric: Approximately 1 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in., in a Leno weave, for ducts.
1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
2.
a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Mast-A-Fab.
b. Vimasco Corporation; Elastafab 894.

3.9 FIELD-APPLIED CLOTHS

A. Woven Glass-Fiber Fabric: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 8 oz./sq. yd..
   1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
      a. Alpha Associates, Inc.; Alpha-Maritex 84215 and 84217/9485RW, Luben 59.

3.10 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.

C. Metal Jacket:
   1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
      a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Metal Jacketing Systems.
      b. ITW Insulation Systems; Aluminum and Stainless Steel Jacketing.
      c. RPR Products, Inc.; Insul-Mate.
   2.
   3. Aluminum Jacket: Comply with ASTM B 209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.
      a. Sheet and roll stock ready for shop or field sizing, Factory cut and rolled to size.
      b. Finish and thickness are indicated in field-applied jacket schedules.
      c. Moisture Barrier for Indoor Applications: 1-mil-thick, heat-bonded polyethylene and kraft paper, 3-mil- thick, heat-bonded polyethylene and kraft paper.
      d. Moisture Barrier for Outdoor Applications: 3-mil-thick, heat-bonded polyethylene and kraft paper.
      e. Factory-Fabricated Fitting Covers:
         1) Same material, finish, and thickness as jacket.
         2) Preformed 2-piece or gore, 45- and 90-degree, short- and longradius elbows.
         3) Tee covers.
         4) Flange and union covers.
         5) End caps.
         6) Beveled collars.
         7) Valve covers.
         8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.
   4. Stainless-Steel Jacket: ASTM A 167 or ASTM A 240/A 240M.

a. Sheet and roll stock ready for shop or field sizing, Factory cut and rolled to size.
b. Material, finish, and thickness are indicated in field-applied jacket schedules.
c. Moisture Barrier for Indoor Applications: 1-mil-thick, heat-bonded polyethylene and kraft paper, 3-mil-thick, heat-bonded polyethylene and kraft paper.
d. Moisture Barrier for Outdoor Applications: 3-mil-thick, heat-bonded polyethylene and kraft paper.
e. Factory-Fabricated Fitting Covers:
1) Same material, finish, and thickness as jacket.
2) Preformed 2-piece or gore, 45- and 90-degree, short- and longradius elbows.
3) Tee covers.
4) Flange and union covers.
5) End caps.
6) Beveled collars.
7) Valve covers.
8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

D. Self-Adhesive Outdoor Jacket: 60-mil- thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a cross-laminated polyethylene film covered with white, stucco-embossed aluminum-foil facing.
1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
a. Polyguard Products, Inc.; Alumaguard 60.
b. Venture Tape Corporation; VentureClad Plus

3.11 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
a. ABI, Ideal Tape Division; 428 AWF ASJ.
b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0836.
c. Compac Corporation; 104 and 105.
d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.
e. Knauf Insulation; EXPERT Tapes: ASJ+ Tape OR ASJ Tape.
f.
2. Width: 3 inches.
3. Thickness: 11.5 mils.

4. Adhesion: 90 ounces force/inch in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.
   1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
      a. ABI, Ideal Tape Division; 491 AWF FSK.
      b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.
      c. Compac Corporation; 110 and 111.
      d. Venture Tape; 1525 CW NT, 1528 CW, and 1528 CW/SQ.
      e. Knauf Insulation; EXPERT Tapes: FSK Tape.
      f.
   2. Width: 3 inches.
   3. Thickness: 6.5 mils.
   4. Adhesion: 90 ounces force/inch in width.
   5. Elongation: 2 percent.
   6. Tensile Strength: 40 lbf/inch in width.
   7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

C. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
   1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
      a. ABI, Ideal Tape Division; 488 AWF.
      b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0800.
      c. Compac Corporation; 120.
      d. Venture Tape; 3520 CW.
      e. Knauf Insulation; EXPERT Tapes: 2 MIL Foil Tape.
      f.
   2. Width: 2 inches.
   3. Thickness: 3.7 mils.
   4. Adhesion: 100 ounces force/inch in width.
   5. Elongation: 5 percent.
   6. Tensile Strength: 34 lbf/inch in width.

3.12 SECUREMENTS

A. Bands:
   1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
      a. ITW Insulation Systems; Gerrard Strapping and Seals.
      b. RPR Products, Inc.; Insul-Mate Strapping, Seals, and Springs.

c. Wing seals are primarily used for fastening bands together. Closed seals are occasionally used for large, 84-inch- diameter applications and where fastening bands are used with springs. Wing seals are reusable; closed seals are not.

d.

2. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304 or Type 316; 0.015 inch thick, 1/2 inch with wing seal or closed seal.
3. Aluminum: ASTM B 209 Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inch wide with wing seal.
4. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.

B. Insulation Pins and Hangers:

1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- or 0.135-inch- diameter shank, length to suit depth of insulation indicated.

a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

1) AGM Industries, Inc.; CWP-1.
2) GEMCO; CD.
3) Midwest Fasteners, Inc.; CD.
4) Nelson Stud Welding; TPA, TPC, and TPS.

b.

2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- or 0.135inch-diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.

a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

1) AGM Industries, Inc.; CHP-1.
2) GEMCO; Cupped Head Weld Pin.
3) Midwest Fasteners, Inc.; Cupped Head. 4) Nelson Stud Welding; CHP.

b.

3. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

1) AGM Industries, Inc.; Tactoo Perforated Base Insul-Hangers.

2) GEMCO; Perforated Base. 3) Midwest Fasteners, Inc.

b.

c. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.

d. Spindle: Copper- or zinc-coated, low-carbon steel, Aluminum and Stainless steel], fully annealed, 0.106-inch- diameter shank, length to suit depth of insulation indicated.

e. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

4. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

1) GEMCO; Nylon Hangers.
2) Midwest Fasteners, Inc.
3)

b. Baseplate: Perforated, nylon sheet, 0.030 inch thick by 1-1/2 inches in diameter.

c. Spindle: Nylon, 0.106-inch- diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches.

d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

5. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

1) AGM Industries, Inc.; Tactoo Self-Adhering Insul-Hangers.
2) GEMCO; Peel and Press.
3) Midwest Fasteners, Inc.
4)

b. Baseplate: Galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.

c. Spindle: Copper- or zinc-coated, low-carbon steel, Aluminum, Stainless steel, fully annealed, 0.106-inch- diameter shank, length to suit depth of insulation indicated.

d. Adhesive-backed base with a peel-off protective cover.

6. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick, galvanized-steel, aluminum, stainless-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
   a. Products: Subject to compliance with requirements,:
      1) AGM Industries, Inc.; RC-150.
      2) GEMCO; R-150.
      3) Midwest Fasteners, Inc.; WA-150.
      4) Nelson Stud Welding;
      5)
   b. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.
7. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
   a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
      1) GEMCO.
      2) Midwest Fasteners, Inc.
   b.

C. Staples: Outward-clinching insulation staples, nominal 3/4-inch- wide, stainless steel or Monel.

D. Wire: [0.080-inch (2.0-mm) nickel-copper alloy, 0.062-inch soft-annealed, galvanized steel.

3.13 CORNER ANGLES

A. Aluminum Corner Angles: 0.040 inch thick, minimum 1 by 1 inch, aluminum according to ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14.

B. Stainless-Steel Corner Angles: 0.024 inch thick, minimum 1 by 1 inch, stainless steel according to ASTM A 167 or ASTM A 240/A 240M, Type 304 or Type 316.

PART 4 - EXECUTION

4.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.
   1. Verify that systems to be insulated have been tested and are free of defects.

2. Verify that surfaces to be insulated are clean and dry.

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

4.2 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

4.3 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of ducts and fittings.

B. Install insulation materials, vapor barriers or retarders, jackets, and thicknesses required for each item of duct system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Keep insulation materials dry during application and finishing.

G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer. H. Install insulation with least number of joints practical.

I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
   1. Install insulation continuously through hangers and around anchor attachments.
   2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
   3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.

J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

K. Install insulation with factory-applied jackets as follows:
1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch- wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches (100 mm) o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 4 inches o.c.
   a. For below ambient services, apply vapor-barrier mastic over staples.
4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct flanges and fittings.

L. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

4.4 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and

outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.

3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
4. Seal jacket to wall flashing with flashing sealant.

C. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

D. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches.
1. Comply with requirements in Section 078413 "Penetration Firestopping."

E. Insulation Installation at Floor Penetrations:
1. Duct: For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches.
2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

4.5 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

4.6 INSTALLATION OF MINERAL-FIBER INSULATION

A. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. Install either capacitor-discharge-weld pins and speed washers or cuppedhead, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
   a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
   b. On duct sides with dimensions larger than 18 inches, place pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.

c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
d. Do not overcompress insulation during installation.
e. Impale insulation over pins and attach speed washers.
f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
   a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
   b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.
5. Overlap unfaced blankets a minimum of 2 inches on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches o.c.
6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

B. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. Install either capacitor-discharge-weld pins and speed washers or cuppedhead, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
   a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.

b. On duct sides with dimensions larger than 18 inches, space pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
d. Do not overcompress insulation during installation.
e. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
   a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
   b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot (5.5-m) intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.
5. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
6. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

4.7 FIELD-APPLIED JACKET INSTALLATION

A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.
   1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.
   2. Embed glass cloth between two 0.062-inch- thick coats of lagging adhesive.
   3. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. Where FSK jackets are indicated, install as follows:
   1. Draw jacket material smooth and tight.

2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.
4. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch- wide joint strips at end joints.
5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

C. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturer's recommended adhesive.
   1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

D. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

4.8 FIRE-RATED INSULATION SYSTEM INSTALLATION

A. Where fire-rated insulation system is indicated, secure system to ducts and duct hangers and supports to maintain a continuous fire rating.

B. Insulate duct access panels and doors to achieve same fire rating as duct.

C. Install firestopping at penetrations through fire-rated assemblies. Fire-stop systems are specified in Section 078413 "Penetration Firestopping."

4.9 FINISHES

A. Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."
   1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.
      a. Finish Coat Material: Interior, flat, latex-emulsion size.

B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

D. Do not field paint aluminum or stainless-steel jackets.

4.10 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Tests and Inspections:
1. Inspect ductwork, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location for each duct system defined in the "Duct Insulation Schedule, General" Article.

D. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

4.11 DUCT INSULATION SCHEDULE, GENERAL

A. Plenums and Ducts Requiring Insulation:
1. Indoor, concealed supply and outdoor air.
2. Indoor, exposed supply and outdoor air.
3. Indoor, concealed return located in unconditioned space.
4. Indoor, exposed return located in unconditioned space.
5. Indoor, concealed, Type I, commercial, kitchen hood exhaust.
6. Indoor, exposed, Type I, commercial, kitchen hood exhaust.
7. Indoor, concealed oven and warewash exhaust.
8. Indoor, exposed oven and warewash exhaust.
9. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
10. Indoor, exposed exhaust between isolation damper and penetration of building exterior.
11. Outdoor, concealed supply and return.
12. Outdoor, exposed supply and return.

B. Items Not Insulated:
1. Fibrous-glass ducts.
2. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1.
3. Factory-insulated flexible ducts.
4. Factory-insulated plenums and casings.
5. Flexible connectors.
6. Vibration-control devices.

7. Factory-insulated access panels and doors.

4.12 INDOOR DUCT AND PLENUM INSULATION SCHEDULE A.

Heating Only Supply Ducts - Climate Zone 4						
Duct Location	Minimum As-Installed R-Value	Insulation Type	Minimum Thickness (inches)	Minimum Density (lb/cu.ft)	Factory Applied Jacket	Field Applied Jacket
Heating Only Supply Ducts - Climate Zone 4						
Duct Location	Minimum As-Installed R-Value	Insulation Type	Minimum Thickness (inches)	Minimum Density (lb/cu.ft)	Factory Applied Jacket	Field Applied Jacket
All rectangular ductwork, plena, duct mounted coils and supply fans exterior to building envelope. Taper insulation to prevent water accumulation by increasing thickness from minimum listed to high point for drainage. Increase insulation thickness 1/8” per foot.	R-3.5	Rigid MineralFiber Board	1.0	6.0	FSK	SelfAdhesive Outdoor Jacket
All round ductwork and supply fans exterior to building envelope.	R-3.5	Semi-Rigid Mineral-Fiber Board	1.0	2.25	FSK	SelfAdhesive Outdoor Jacket
All flat oval ductwork exterior to building envelope. Taper insulation to prevent water accumulation by increasing thickness from minimum listed to high point for drainage. Increase insulation thickness 1/8” per foot.	R-3.5	Semi-Rigid Mineral-Fiber Board	1.0	2.25	FSK	SelfAdhesive Outdoor Jacket

B.

C. D.

Cooling Only Supply Ducts - Climate Zone 4						
Duct Location	Minimum As-Installed R-Value	Insulation Type	Minimum Thickness (inches)	Minimum Density (lb/cu.ft)	Factory Applied Jacket	Field Applied Jacket

All rectangular ductwork, plena, duct mounted coils and supply fans exterior to building envelope. Taper insulation to prevent water accumulation by increasing thickness from minimum listed to high point for drainage. Increase insulation thickness 1/8” per foot.	R-3.5	Rigid Mineral-Fiber Board	1.0	6.0	FSK	SelfAdhesive Outdoor Jacket
All round ductwork and supply fans exterior to building envelope.	R-3.5	Semi-Rigid MineralFiber Board	1.0	2.25	FSK	SelfAdhesive Outdoor Jacket
All flat oval ductwork exterior to building envelope. Taper insulation on flat oval duct to prevent water accumulation by increasing thickness from minimum listed to high point for drainage. Increase insulation thickness 1/8” per foot.	R-3.5	Semi-Rigid MineralFiber Board	1.0	2.25	FSK	SelfAdhesive Outdoor Jacket
Cooling Only Supply Ducts - Climate Zone 4						
Duct Location	Minimum As-Installed R-Value	Insulation Type	Minimum Thickness (inches)	Minimum Density (lb/cu.ft)	Factory Applied Jacket	Field Applied Jacket
All concealed ductwork, plena, duct mounted coils and supply fans in unconditioned spaces including shafts, non-plenum return ceiling cavities and crawlspaces (ventilated and non- ventilated) and all exposed ductwork 10 feet or more above finished floor.	R-1.9	Mineral-Fiber Blanket	1.0	0.75	FSK	N/A
		Semi-Rigid MineralFiber Board	1.0	2.25	FSK	N/A
		Flexible Elastomeric	0.5	N/A	N/A	N/A
All concealed ductwork, plena, duct mounted coils and supply fans in indirectly conditioned spaces (active ceiling return plenums).	None	N/A	N/A	N/A	N/A	N/A
All rectangular ductwork plena, duct mounted coils and supply fans in mechanical rooms and all rectangular ductwork and plena in exposed location below 10 feet above finished floor.	R-1.9	Rigid Mineral-Fiber Board	1.0	3.0	FSK	N/A
All round ductwork and supply fans in mechanical rooms and all round ductwork in exposed location below 10 feet above finished floor.	R-1.9	Semi-Rigid MineralFiber Board	1.0	2.25	FSK	N/A

Unconditioned Outside Air Intake Ducts/Plena and Exhaust/Relief Duct/Plena Inside Building Envelope – Climate Zones 4						
Duct Location	Minimum As-Installed R-Value	Insulation Type	Minimum Thickness (inches)	Minimum Density (lb/cu.ft)	Factory Applied Jacket	Field Applied Jacket
For outside air intakes, all rectangular ductwork and plena between the building envelope and the first system heating coil, cooling coil or air handling unit connection.	R-6	Rigid Mineral-Fiber Board	1.5	6.0	FSK	N/A
For outside air intakes, all round ductwork between the building envelope and the first system heating coil, cooling coil or air handling unit connection.	R-6	Semi-Rigid MineralFiber Board	1.5	1.5	FSK	N/A
For exhaust/relief ducts and plena, all rectangular ductwork and plena between the building envelope and first system isolation damper.	R-6	Rigid Mineral-Fiber Board	1.5	6.0	FSK	N/A
For exhaust/relief ducts all round ductwork between the building envelope and first system isolation damper.	R-6	Semi-Rigid MineralFiber Board	1.5	1.5	FSK	N/A

Return Ducts/Plena, Oven, Dishwasher, Ware-washer, Shower and Heat/Energy Recovery System Exhaust Ducts - Climate Zones 4						
Duct Location	Minimum As-Installed R-Value	Insulation Type	Minimum Thickness (inches)	Minimum Density (lb/cu.ft)	Factory Applied Jacket	Field Applied Jacket
All rectangular ductwork and plena exterior to building enve-lope. For exterior ductwork taper insulation to prevent water ac-cumulation by increasing thickness from minimum listed to high point for drainage.	R-3.5	Rigid Mineral-Fiber Board	1.0	6.0	FSK	SelfAdhesive Outdoor Jacket
All round ductwork exterior to building envelope.	R-3.5	Semi-Rigid MineralFiber Board	1.0	2.25	FSK	SelfAdhesive Outdoor Jacket
All rectangular ductwork and plena in unconditioned shafts and in mechanical spaces (prior to recovery device or air handling unit return connection only).	R-3.5	Rigid Mineral-Fiber Board	1.0	6.0	FSK	N/A

All round ductwork in unconditioned shafts and in all mechanical spaces (prior to recovery device or air handling unit return connection only).	R-3.5	Semi-Rigid MineralFiber Board	1.0	2.25	FSK	N/A

Concealed, Type I (Grease), Commercial, Kitchen Hood Exhaust Duct and Plena - Climate Zones 4						
Duct Location	Minimum As-Installed R-Value	Insulation Type	Minimum Thickness (inches)	Minimum Density (lb/cu.ft)	Factory Applied Jacket	Field Applied Jacket
All ductwork and plena.	N/A	Fire Rated Blanket or Fire Rated Board	Number of Layers and Thickness Required to Meet 2- Hour Fire Rating for Grease Ducts	N/A	N/A	N/A

Indoor Concealed and Exposed Ducts Identified as Requiring Fire Rated Insulation - Climate Zones 1 Through 8						
Duct Location	Minimum As-Installed R-Value	Insulation Type	Minimum Thickness (inches)	Minimum Density (lb/cu.ft)	Factory Applied Jacket	Field Applied Jacket
All ductwork and plena.	N/A	Fire Rated Blanket or Fire Rated Board	Number of Layers and Thickness Required to Meet Re-quired Fire Rating for Ventilation Ducts	N/A	N/A	N/A

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Combined Heating and Cooling Supply Ducts - Climate Zone 4						
Duct Location	Minimum As-Installed R-Value	Insulation Type	Minimum Thickness (inches)	Minimum Density (lb/cu.ft)	Factory Applied Jacket	Field Applied Jacket

All rectangular ductwork, plena, duct mounted coils and supply fans exterior to building envelope. Taper insulation to prevent water accumulation by increasing thickness from minimum listed to high point for drainage. Increase insulation thickness 1/8" per foot.	R-6	Rigid MineralFiber Board	1.5	6.0	FSK	SelfAdhesive Outdoor Jacket
All round ductwork and supply fans exterior to building envelope.	R-6	Semi-Rigid Mineral-Fiber Board	1.5	1.5	FSK	SelfAdhesive Outdoor Jacket
All flat oval ductwork exterior to building envelope. Taper insulation on flat oval duct to prevent water accumulation by increasing thickness from minimum listed to high point for drainage. Increase insulation thickness 1/8" per foot.	R-6	Semi-Rigid Mineral-Fiber Board	1.5	1.5	FSK	SelfAdhesive Outdoor Jacket
All concealed ductwork plena, duct mounted coils and supply fans in unconditioned spaces including shafts, non-plenum return ceiling cavities and crawlspaces (ventilated and non- ventilated) and all exposed ductwork 10 feet or more above finished floor.	R-3.5	Mineral-Fiber Blanket	1.5	0.75	FSK	N/A
		Semi-Rigid Mineral-Fiber Board	1.0	2.25	FSK	N/A
		Flexible Elastomeric	1.0	N/A	N/A	N/A
All concealed ductwork, plena, duct mounted coils and supply fans in indirectly conditioned spaces (active ceiling return plenums).	None	N/A	N/A	N/A	N/A	N/A
All rectangular ductwork plena, duct mounted coils and supply fans in mechanical rooms and all rectangular ductwork and plena in exposed location below 10 feet above finished floor.	R-3.5	Rigid MineralFiber Board	1.0	3.0	FSK	N/A
All round ductwork and supply fansin mechanical rooms and all round ductwork in exposed location below 10 feet above finished floor.	R-3.5	Semi-Rigid Mineral-Fiber Board	1.0	2.25	FSK	N/A

H.

4.13 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Ducts and Plenums, Exposed, Larger Than 48 Inches in Diameter or with Flat Surfaces Larger Than 72 Inches:

1. Painted Aluminum, Smooth or Stucco Embossed with corrugation depth and thickness recommended by the insulation manufacturer.

END OF SECTION

SECTION 230719
HVAC PIPING INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes insulating the following HVAC piping systems:

1. Condensate drain piping, indoors and outdoors.
2. Chilled-water and brine piping, indoors.
3. Heating hot-water piping, indoors.
4. Steam and steam condensate piping, indoors and outdoors.
5. Refrigerant suction and hot-gas piping, indoors and outdoors.

B. Related Sections:

1. Section 230713 "Duct Insulation."
2. Section 230716 "HVAC Equipment Insulation."

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory and field applied if any).

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
2. Detail attachment and covering of heat tracing inside insulation.
3. Detail insulation application at pipe expansion joints for each type of insulation.
4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
5. Detail removable insulation at piping specialties.
6. Detail application of field-applied jackets.
7. Detail application at linkages of control devices.

C. Samples: For each type of insulation and jacket indicated. Identify each Sample, describing product and intended use.

1. Preformed Pipe Insulation Materials: 12 inches long by NPS 2.
2. Sheet Form Insulation Materials: 12 inches square.
3. Jacket Materials for Pipe: 12 inches long by NPS 2.
4. Sheet Jacket Materials: 12 inches square.
5. Manufacturer's Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

B. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed. C. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smokedeveloped index of 50 or less.
2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smokedeveloped index of 150 or less.

C. Mockups: Before installing insulation, build mockups for each type of insulation and finish listed below to demonstrate quality of insulation application and finishes. Build mockups in the location indicated or, if not indicated, as directed by Architect. Use materials indicated for the completed Work.

1. Piping Mockups:

   a. One 10-foot section of NPS 2 straight pipe.
   b. One each of a 90-degree threaded, welded, and flanged elbow.
   c. One each of a threaded, welded, and flanged tee fitting.
   d. One NPS 2 or smaller valve, and one NPS 2-1/2 or larger valve.
   e. Four support hangers including hanger shield and insert.

f. One threaded strainer and one flanged strainer with removable portion of insulation.
g. One threaded reducer and one welded reducer.
h. One pressure temperature tap.
i. One mechanical coupling.

2. For each mockup, fabricate cutaway sections to allow observation of application details for insulation materials, adhesives, mastics, attachments, and jackets.
3. Notify Architect seven days in advance of dates and times when mockups will be constructed.
4. Obtain Architect's approval of mockups before starting insulation application.
5. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
6. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
7. Demolish and remove mockups when directed.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.7 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

B. Coordinate clearance requirements with piping Installer for piping insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

C. Coordinate installation and testing of heat tracing.

1.8 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Comply with requirements in "Piping Insulation Schedule, General," "Indoor Piping Insulation Schedule," "Outdoor, Aboveground Piping Insulation Schedule," and "Outdoor, Underground Piping Insulation Schedule" articles for where insulating materials shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. Calcium Silicate:

1. Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
    a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-97.
    b. Eagle Bridges - Marathon Industries; 290.
    c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 81-27.
    d. Mon-Eco Industries, Inc. 22-30.
    e. Vimasco Corporation; 760.

2. Preformed Pipe Sections: Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C 533, Type I.
3. Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C 533, Type I.
4. Prefabricated Fitting Covers: Comply with ASTM C 450 and ASTM C 585 for dimensions used in preforming insulation to cover valves, elbows, tees, and flanges.

G. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 81-84.

2. Block Insulation: ASTM C 552, Type I.
3. Special-Shaped Insulation: ASTM C 552, Type III.
4. Board Insulation: ASTM C 552, Type IV.
5. Preformed Pipe Insulation without Jacket: Comply with ASTM C 552, Type II, Class 1.
6. Preformed Pipe Insulation with Factory-Applied ASJ, ASJ-SSL: Comply with ASTM C 552, Type II, Class 2.
7. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.

H. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type I, II with factory-applied vinyl jacket, III with factory-applied FSK jacket, III with factory-applied FSP jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

   a. Johns Manville; a Berkshire Hathaway company.

   b. Knauf Insulation.

   c. Manson Insulation Inc.

   d. Owens Corning.

I. Mineral-Fiber, Preformed Pipe Insulation:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

   a. CertainTeed Corp.; CrimpWrap.

   b. Johns Manville; MicroFlex.

   c. Knauf Insulation; Earthwool Pipe & Tank Insulation with ECOSE Technology.

   d. Knauf Insulation: Kwik-Flex Pipe & Tank Insulation.

   e. Manson Insulation Inc.; AK Flex.

   f. Owens Corning; Fiberglas Pipe and Tank Insulation.

2. Type I, 850 deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, without factory-applied jacket, with factory-applied ASJ, with factory-applied ASJ-SSL. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
3. Type II, 1200 deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type II, Grade A, without factory-applied jacket, with factory-applied ASJ, with factory-applied ASJ-SSL.

Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

J. Mineral-Fiber, Pipe Insulation Wicking System: Preformed pipe insulation complying with ASTM C 547, Type I, Grade A, with absorbent cloth factory-applied to the entire inside surface of preformed pipe insulation and extended through the longitudinal joint to outside surface of insulation under insulation jacket. Factory apply a white, polymer, vapor-retarder jacket with self-sealing adhesive tape seam and evaporation holes running continuously along the longitudinal seam, exposing the absorbent cloth.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

    a. CertainTeed Corp.; CrimpWrap.

    b. Johns Manville; MicroFlex.

    c. Knauf Insulation; Earthwool Pipe & Tank Insulation with ECOSE Technology.

    d. Knauf Insulation: Kwik-Flex Pipe & Tank Insulation.

    e. Manson Insulation Inc.; AK Flex.

    f. Owens Corning; Fiberglas Pipe and Tank Insulation.

K. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied ASJ, FSK jacket complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb/cu. ft. or more. Thermal conductivity (k-value) at 100 deg F is 0.29 Btu x in./h x sq. ft. x deg F or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

    a. CertainTeed Corp.; CrimpWrap.

    b. Johns Manville; MicroFlex.

    c. Knauf Insulation; Earthwool Pipe & Tank Insulation with ECOSE Technology.

    d. Knauf Insulation: Kwik-Flex Pipe & Tank Insulation.

    e. Manson Insulation Inc.; AK Flex.

    f. Owens Corning; Fiberglas Pipe and Tank Insulation.

2.2 INSULATING CEMENTS

A. Mineral-Fiber Insulating Cement: Comply with ASTM C 195.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

    a. Ramco Insulation, Inc.; Super-Stik.

B. Expanded or Exfoliated Vermiculite Insulating Cement: Comply with ASTM C 196.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

    a. Ramco Insulation, Inc.; Super-Stik.

C. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

    a. Ramco Insulation, Inc.; Super-Stik.

2.3 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

B. Calcium Silicate Adhesive: Fibrous, sodium-silicate-based adhesive with a service temperature range of 50 to 800 deg F.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

    a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-97.

    b. Eagle Bridges - Marathon Industries; 290.

    c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 81-27.

    d. Mon-Eco Industries, Inc. 22-30.

    e. Vimasco Corporation; 760.

C. Cellular-Glass Adhesive: Two-component, thermosetting urethane adhesive containing no flammable solvents, with a service temperature range of minus 100 to plus 200 deg F.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

    a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 81-84.

D. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Aeroflex USA, Inc.; Aeroseal Low VOC.

b. Armacell LLC; Armaflex 520BLV Adhesive.

c. K-Flex USA; 720-LVOC Contact Adhesive.

d. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-75.

E. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-127.

b. Eagle Bridges - Marathon Industries; 225.

c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-60/85-70.

F. ASJ Adhesive, and FSK and PVDC Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-82.

b. Eagle Bridges - Marathon Industries; 225.

c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-50.

d. Mon-Eco Industries, Inc.; 22-25.

2.4 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.

1. VOC Content: 300 g/L or less.

2. Low-Emitting Materials: Mastic coatings shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." The building concentration of formaldehyde shall not exceed half of the indoor recommended exposure limit, 9 mcg/cu. m or 7 ppb, whichever is less, and that of acetaldehyde shall not exceed 9 mcg/cu. m.

B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below-ambient services.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
   a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-80/30-90.
   b. Vimasco Corporation; 749.
2. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm at 43mil dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F.
4. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
5. Color: White.

C. Vapor-Barrier Mastic: Solvent based; suitable for indoor use on below-ambient services.
1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Encacel.
   b. Eagle Bridges - Marathon Industries; 570.
   c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 60-95/60-96.
2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 35-mil dry film thickness.
3. Service Temperature Range: 0 to 180 deg F.
4. Solids Content: ASTM D 1644, 44 percent by volume and 62 percent by weight.
5. Color: White.

D. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below-ambient services.
1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Encacel.
   b. Eagle Bridges - Marathon Industries; 570.
   c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 60-95/60-96.
2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 30-mil dry film thickness.
3. Service Temperature Range: Minus 50 to plus 220 deg F.
4. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.
5. Color: White.

E. Breather Mastic: Water based; suitable for indoor and outdoor use on aboveambient services.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-10.
   b. Eagle Bridges - Marathon Industries; 550.
   c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 46-50.
   d. Mon-Eco Industries, Inc.; 55-50.
   e. Vimasco Corporation; WC-1/WC-5.
2. Water-Vapor Permeance: ASTM F 1249, 1.8 perms at 0.0625-inch dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F.
4. Solids Content: 60 percent by volume and 66 percent by weight.
5. Color: White.

2.5 LAGGING ADHESIVES

A. Description: Comply with MIL-A-3316C, Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-50 AHV2.
   b. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-36.
   c. Vimasco Corporation; 713 and 714.
2. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over pipe insulation.
3. Adhesives shall have a VOC content of 250 g/L or less.
4. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." The building concentration of formaldehyde shall not exceed half of the indoor recommended exposure limit, 9 mcg/cu. m or 7 ppb, whichever is less, and that of acetaldehyde shall not exceed 9 mcg/cu. m.
5. Service Temperature Range: 0 to plus 180 deg F.
6. Color: White.

2.6 SEALANTS

A. FSK and Metal Jacket Flashing Sealants:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

    a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.

    b. Eagle Bridges - Marathon Industries; 405.

    c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 95-44.

    d. Mon-Eco Industries, Inc.; 44-05.

2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F.
5. Color: Aluminum.
6. Sealant shall have a VOC content of 420 g/L or less.
7. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." The building concentration of formaldehyde shall not exceed half of the indoor recommended exposure limit, 9 mcg/cu. m or 7 ppb, whichever is less, and that of acetaldehyde shall not exceed 9 mcg/cu. m.

B. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
    a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F.
5. Color: White.

2.7 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.

4. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C 1136, Type II.

2.8 FIELD-APPLIED FABRIC-REINFORCING MESH

A. Woven Glass-Fiber Fabric: Approximately 2 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in. for covering pipe and pipe fittings.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Chil-Glas No. 5.

B. Woven Polyester Fabric: Approximately 1 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in., in a Leno weave, for pipe.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Mast-A-Fab.
b. Vimasco Corporation; Elastafab 894.

2.9 FIELD-APPLIED CLOTHS

A. Woven Glass-Fiber Fabric: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 8 oz./sq. yd.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Alpha Associates, Inc.; Alpha-Maritex 84215 and 84217/9485RW, Luben 59.

2.10 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.

C. Metal Jacket:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Metal Jacketing Systems.

b. ITW Insulation Systems; Aluminum and Stainless Steel Jacketing.

c. RPR Products, Inc.; Insul-Mate.

2. Aluminum Jacket: Comply with ASTM B 209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.

a. Sheet and roll stock ready for shop or field sizing, Factory cut and rolled to size.
b. Finish and thickness are indicated in field-applied jacket schedules.
c. Moisture Barrier for Indoor Applications: 1-mil-thick, heat-bonded polyethylene and kraft paper, 3-mil- thick, heat-bonded polyethylene and kraft paper.
d. Moisture Barrier for Outdoor Applications: 3-mil-thick, heat-bonded polyethylene and kraft paper.
e. Factory-Fabricated Fitting Covers:

1) Same material, finish, and thickness as jacket.
2) Preformed 2-piece or gore, 45- and 90-degree, short- and longradius elbows.
3) Tee covers.
4) Flange and union covers.
5) End caps.
6) Beveled collars.
7) Valve covers.
8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

3. Stainless-Steel Jacket: ASTM A 167 or ASTM A 240/A 240M.

a. Sheet and roll stock ready for shop or field sizing, Factory cut and rolled to size.
b. Material, finish, and thickness are indicated in field-applied jacket schedules.
c. Moisture Barrier for Indoor Applications: 1-mil-thick, heat-bonded polyethylene and kraft paper, 3-mil-thick, heat-bonded polyethylene and kraft paper.
d. Moisture Barrier for Outdoor Applications: 3-mil-thick, heat-bonded polyethylene and kraft paper.
e. Factory-Fabricated Fitting Covers:

1) Same material, finish, and thickness as jacket.
2) Preformed 2-piece or gore, 45- and 90-degree, short- and longradius elbows.
3) Tee covers.
4) Flange and union covers.
5) End caps.
6) Beveled collars.
7) Valve covers.

8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

D. Underground Direct-Buried Jacket: 125-mil-thick vapor barrier and waterproofing membrane consisting of a rubberized bituminous resin reinforced with a wovenglass fiber or polyester scrim and laminated aluminum foil.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Pittsburgh Corning Corporation; Pittwrap.

b. Polyguard Products, Inc.; Insulrap No Torch 125.

E. Self-Adhesive Outdoor Jacket: 60-mil-thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a cross-laminated polyethylene film covered with white, stucco-embossed aluminum-foil facing.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Polyguard Products, Inc.; Alumaguard 60.

b. Venture Tape Corporation; VentureClad Plus

2.11 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. ABI, Ideal Tape Division; 428 AWF ASJ.

b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0836.

c. Compac Corporation; 104 and 105.

d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.

e. Knauf Insulation; EXPERT Tapes: ASJ+ Tape OR ASJ Tape.

2. Width: 3 inches.
3. Thickness: 11.5 mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
    a. ABI, Ideal Tape Division; 491 AWF FSK.
    b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.
    c. Compac Corporation; 110 and 111.
    d. Venture Tape; 1525 CW NT, 1528 CW, and 1528 CW/SQ.
    e. Knauf Insulation; EXPERT Tapes: FSK Tape.
2. Width: 3 inches.
3. Thickness: 6.5 mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

C. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
    a. ABI, Ideal Tape Division; 488 AWF.
    b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0800.
    c. Compac Corporation; 120.
    d. Venture Tape; 3520 CW.
    e. Knauf Insulation; EXPERT Tapes: 2 MIL Foil Tape.
2. Width: 2 inches.
3. Thickness: 3.7 mils.
4. Adhesion: 100 ounces force/inch in width.
5. Elongation: 5 percent.
6. Tensile Strength: 34 lbf/inch in width.

2.12 SECUREMENTS

A. Bands:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
    a. ITW Insulation Systems; Gerrard Strapping and Seals.
    b. RPR Products, Inc.; Insul-Mate Strapping, Seals, and Springs.
2. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304 or Type 316;

0.015 inch thick, 1/2 inch with wing seal or closed seal.

3. Aluminum: ASTM B 209 Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inch wide with wing seal.
4. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.

B. Staples: Outward-clinching insulation staples, nominal 3/4-inch- wide, stainless steel or Monel.

C. Wire: 0.080-inch nickel-copper alloy, 0.062-inch soft-annealed, stainless steel, 0.062-inch soft-annealed, galvanized steel. **PART 3 - EXECUTION**

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.

1. Verify that systems to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.
3. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

B. Surface Preparation: Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:

1. Stainless Steel: Coat 300 series stainless steel with an epoxy primer 5 mils thick and an epoxy finish 5 mils thick if operating in a temperature range between 140 and 300 deg F. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
2. Carbon Steel: Coat carbon steel operating at a service temperature between 32 and 300 deg F with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

C. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

D. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping including fittings, valves, and specialties.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of pipe system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

G. Keep insulation materials dry during application and finishing.

H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer. I. Install insulation with least number of joints practical.

J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

L. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch-wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive selfsealing lap. Staple laps with outward clinching staples along edge at 4 inches o.c.

    a. For below-ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.

M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

P. For above-ambient services, do not install insulation to the following:

1. Vibration-control devices.
2. Testing agency labels and stamps.
3. Nameplates and data plates.
4. Manholes.
5. Handholes.
6. Cleanouts.

3.4 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.

C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
4. Seal jacket to wall flashing with flashing sealant.

D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.

1. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping and fire-resistive joint sealers. F. Insulation Installation at Floor Penetrations:

1. Pipe: Install insulation continuously through floor penetrations.
2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.5 GENERAL PIPE INSULATION INSTALLATION

A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:

1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe

insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.

4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.
6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabricreinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
9. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.

C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

D. Install removable insulation covers at locations indicated. Installation shall conform to the following:

1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.

4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.
5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.6 INSTALLATION OF CALCIUM SILICATE INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure single-layer insulation with stainless-steel bands at 12-inch intervals and tighten bands without deforming insulation materials.
2. Install two-layer insulation with joints tightly butted and staggered at least 3 inches. Secure inner layer with wire spaced at 12-inch intervals. Secure outer layer with stainless-steel bands at 12-inch intervals.
3. Apply a skim coat of mineral-fiber, hydraulic-setting cement to insulation surface. When cement is dry, apply flood coat of lagging adhesive and press on one layer of glass cloth or tape. Overlap edges at least 1 inch. Apply finish coat of lagging adhesive over glass cloth or tape. Thin finish coat to achieve smooth, uniform finish.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of block insulation of same material and thickness as pipe insulation.
4. Finish flange insulation same as pipe insulation. C. Insulation Installation on

Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When preformed insulation sections of insulation are not available, install mitered sections of calcium silicate insulation. Secure insulation materials with wire or bands.
3. Finish fittings insulation same as pipe insulation. D. Insulation

Installation on Valves and Pipe Specialties:

1. Install mitered segments of calcium silicate insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
2. Install insulation to flanges as specified for flange insulation application.
3. Finish valve and specialty insulation same as pipe insulation.

3.7 INSTALLATION OF CELLULAR-GLASS INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above-ambient services, secure laps with outward-clinched staples at 6 inches o.c.
4. For insulation with factory-applied jackets on below-ambient services, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vaporbarrier mastic and flashing sealant. B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of cellularglass block insulation of same thickness as pipe insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When preformed sections of insulation are not available, install mitered sections of cellular-glass insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of cellular-glass insulation to valve body.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

3.8 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Flanges:

1. Install pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install mitered sections of pipe insulation.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed valve covers manufactured of same material as pipe insulation when available.
2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.
4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.9 INSTALLATION OF MINERAL-FIBER INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above-ambient surfaces, secure laps with outward-clinched staples at 6 inches o.c.
4. For insulation with factory-applied jackets on below-ambient surfaces, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive as

recommended by insulation material manufacturer and seal with vaporbarrier mastic and flashing sealant. B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch and seal joints with flashing sealant. C. Insulation Installation on Pipe Fittings and Elbows:

   1. Install preformed sections of same material as straight segments of pipe insulation when available.
   2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands. D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
4. Install insulation to flanges as specified for flange insulation application.

3.10 FIELD-APPLIED JACKET INSTALLATION

A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.

1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.
2. Embed glass cloth between two 0.062-inch- thick coats of lagging adhesive.
3. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. Where FSK jackets are indicated, install as follows:

1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.
4. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch- wide joint strips at end joints.
5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

C. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications. Seal with manufacturer's recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

D. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

3.11 FINISHES

A. Pipe Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."

1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.

   a. Finish Coat Material: Interior, flat, latex-emulsion size.

B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

D. Do not field paint aluminum or stainless-steel jackets.

3.12 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Tests and Inspections:

1. Inspect pipe, fittings, strainers, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three locations of straight pipe, three locations of threaded fittings, three locations of welded fittings, two locations of threaded strainers, two locations of welded strainers, three locations of threaded valves, and three locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.

D. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.13 PIPING INSULATION SCHEDULE, GENERAL

A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.

B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:

1. Drainage piping located in crawl spaces.
2. Underground piping.
3. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.14 INDOOR PIPING INSULATION SCHEDULE

A. Provide insulation materials and thicknesses scheduled for each system type and pressure/temperature range. If more than one material is listed for a system, selection from materials listed is Division 23 option.

B. For dual temperature systems (heating and cooling), provide thickness equal to greater of heating or cooling scheduled value. Dual temperature piping shall also meet all vapor barrier requirements for cooling insulation (perm rating). C. Insulation for pre-insulated piping shall meet all specified requirements.

D. Insulate piping operating at temperatures below 40 deg F and systems operating between 40 deg F to 65 deg F in accordance with NAIMA Guide to Insulating Chilled Water Piping Systems with Mineral Fiber Pipe Insulation. Comply with all recommendations including but not limited to the requirement for vapor dams every fourth section of insulation.

E. Pipe Insulation Schedules:

Steam/Steam Condensate Return: 116 psig or Higher/351 deg F or Higher						
Insulation Conductivity Btu-in/hr-deg F-SF at Mean Temp (deg F)	Insulation Type	Pipe Size (inch)	Indoor - Minimum Thickness (inch)	Outdoor Minimum Thickness (inch)	Factory Applied Jacket	Field Applied Jacket
0.32 to 0.34 at 250	Mineral Fiber (Fiberglass) Preformed Pipe, Type I or Type II or Pipe and Tank Insulation for 14” and Larger Pipe Size	Less than 1	4.5	4.5	ASJ or ASJ-SSL	Indoor: N/A Outdoor: Aluminum with Moisture Barrier
		1 to Less than 1.5	5.0	5.0		Indoor: N/A Outdoor: Aluminum with Moisture Barrier
		1.5 to Less than 4	5.0	5.0		Indoor: N/A Outdoor: Aluminum with Moisture Barrier

		4 to Less than 8	5.0	5.0		Indoor: N/A Outdoor: Aluminum with Moisture Barrier
		8 and Larger	5.0	5.0		Indoor: N/A Outdoor: Aluminum with Moisture Barrier

Steam/Steam Condensate Return: 16 psig to 115 psig/251 deg F to 350 deg F						
Insulation Conductivity Btu-in/hr-deg F-SF at Mean Temp (deg F)	Insulation Type	Pipe Size (inch)	Indoor - Minimum Thickness (inch)	Outdoor Minimum Thickness (inch)	Factory Applied Jacket	Field Applied Jacket
0.29 to 0.32 at 200	Mineral Fiber (Fiberglass) Preformed Pipe, Type I or Type II or Pipe and Tank Insulation for 14” and Larger Pipe Size	Less than 1	3.0	4.0	ASJ or ASJ-SSL	Indoor: N/A Outdoor: Aluminum with Moisture Barrier
		1 to Less than 1.5	4.0	4.0		Indoor: N/A Outdoor: Aluminum with Moisture Barrier
		1.5 to Less than 4	4.5	4.5		Indoor: N/A Outdoor: Aluminum with Moisture Barrier
		4 to Less than 8	4.5	4.5		Indoor: N/A Outdoor: Aluminum with Moisture Barrier
		8 and Larger	4.5	4.5		Indoor: N/A Outdoor: Aluminum with Moisture Barrier

Steam/Steam Condensate Return: 0 psig to 15 psig/201 deg F to 250 deg F						
Insulation Conductivity Btu-in/hr-deg F-SF at Mean Temp (deg F)	Insulation Type	Pipe Size (inch)	Indoor - Minimum Thickness (inch)	Outdoor Minimum Thickness (inch)	Factory Applied Jacket	Field Applied Jacket
0.27 to 0.30 at 150	Mineral Fiber (Fiberglass) Preformed Pipe, Type I or Type II or Pipe and Tank Insulation for 14” and Larger Pipe Size	Less than 1	2.5	4.0	ASJ or ASJ-SSL	Indoor: N/A Outdoor: Aluminum with Moisture Barrier
		1 to Less than 1.5	2.5	4.0		Indoor: N/A Outdoor: Aluminum with Moisture Barrier
		1.5 to Less than 4	2.5	4.0		Indoor: N/A Outdoor: Aluminum with Moisture Barrier
		4 to Less than 8	3.0	4.0		Indoor: N/A Outdoor: Aluminum with Moisture Barrier
		8 and Larger	3.0	4.0		Indoor: N/A Outdoor: Aluminum with Moisture Barrier

Steam Pressure Relief: All Pressures/Temperatures						
Insulation Conductivity Btu-in/hr-deg F-SF at Mean Temp (deg F)	Insulation Type	Pipe Size (inch)	Indoor - Minimum Thickness (inch)	Outdoor Minimum Thickness (inch)	Factory Applied Jacket	Field Applied Jacket

0.27 to 0.30 at 150 Applies to piping 24" NPS or smaller, fiberglass insulation with ASJ and pressures up to 200 psig	Mineral Fiber (Fiberglass) Preformed Pipe, Type I or Type II or Pipe and Tank Insulation for 14" and Larger Pipe Size Insulation for 14" and Larger Pipe Size	Less than 1	0.75	N/A	ASJ or ASJ-SSL	Indoor: N/A Outdoor: Aluminum with Moisture Barrier
		1 to Less than 1.5	0.75	N/A		Indoor: N/A Outdoor: Aluminum with Moisture Barrier
		1.5 to Less than 4"	0.75	N/A		Indoor: N/A Outdoor: Aluminum with Moisture Barrier
		4 to Less than 8	0.75	N/A		Indoor: N/A Outdoor: Aluminum with Moisture Barrier
		8 and Larger	0.75	N/A		Indoor: N/A Outdoor: Aluminum with Moisture Barrier

Heating Hot Water Systems: 351 deg F or Higher						
Insulation Conductivity Btu-in/hr-deg F-SF at Mean Temp (deg F)	Insulation Type	Pipe Size (inch)	Indoor - Minimum Thickness (inch)	Outdoor Minimum Thickness (inch)	Factory Applied Jacket	Field Applied Jacket
0.32 to 0.34 at 250	Mineral Fiber (Fiberglass) Preformed Pipe, Type I or Type II or Pipe and Tank Insulation for 14" and Larger Pipe Size	Less than 1	4.5	4.5	ASJ or ASJ-SSL	Indoor: N/A Outdoor: Aluminum with Moisture Barrier
		1 to Less than 1.5	5.0	5.0		Indoor: N/A Outdoor: Aluminum with Moisture Barrier
		1.5 to Less than 4	5.0	5.0		Indoor: N/A Outdoor: Aluminum with Moisture Barrier
		4 to Less than 8	5.0	5.0		Indoor: N/A Outdoor: Aluminum with Moisture Barrier
		8 and Larger	5.0	5.0		Indoor: N/A Outdoor: Aluminum with Moisture Barrier

Heating Hot Water Systems: 251 deg F to 350 deg F						
Insulation Conductivity Btu-in/hr-deg F-SF at Mean Temp (deg F)	Insulation Type	Pipe Size (inch)	Indoor - Minimum Thickness (inch)	Outdoor Minimum Thickness (inch)	Factory Applied Jacket	Field Applied Jacket
0.29 to 0.32 at 200	Mineral Fiber (Fiberglass) Preformed Pipe, Type I or Type II) or Pipe and Tank Insulation for 14" and Larger Pipe Size	Less than 1	3.0	4.0	ASJ or ASJ-SSL	Indoor: N/A Outdoor: Aluminum with Moisture Barrier
		1 to Less than 1.5	4.0	4.0		Indoor: N/A Outdoor: Aluminum with Moisture Barrier
		1.5 to Less than 4	4.5	4.5		Indoor: N/A Outdoor: Aluminum with Moisture Barrier
		4 to Less than 8	4.5	4.5		Indoor: N/A Outdoor: Aluminum with Moisture Barrier

		8 and Larger	4.5	4.5		Indoor: N/A Outdoor: Aluminum with Moisture Barrier

Heating Hot Water Systems: 201 deg F to 250 deg F						
Insulation Conductivity Btu-in/hr-deg F-SF at Mean Temp (deg F)	Insulation Type	Pipe Size (inch)	Indoor - Minimum Thickness (inch)	Outdoor Minimum Thickness (inch)	Factory Applied Jacket	Field Applied Jacket
0.27 to 0.30 at 150	Mineral Fiber (Fiberglass) Preformed Pipe, Type I or Type II or Pipe and Tank Insulation for 14" and Larger Pipe Size	Less than 1	2.5	4.0	ASJ or ASJ-SSL	Indoor: N/A Outdoor: Aluminum with Moisture Barrier
		1 to Less than 1.5	2.5	4.0		Indoor: N/A Outdoor: Aluminum with Moisture Barrier
		1.5 to Less than 4	2.5	4.0		Indoor: N/A Outdoor: Aluminum with Moisture Barrier
		4 to Less than 8	3.0	4.0		Indoor: N/A Outdoor: Aluminum with Moisture Barrier
		8 and Larger	3.0	4.0		Indoor: N/A Outdoor: Aluminum with Moisture Barrier

Heating Hot Water Systems: 141 deg F to 200 deg F						
Insulation Conductivity Btu-in/hr-deg F-SF at Mean Temp (deg F)	Insulation Type	Pipe Size (inch)	Indoor - Minimum Thickness (inch)	Outdoor Minimum Thickness (inch)	Factory Applied Jacket	Field Applied Jacket
0.25 to 0.29 at 125	Mineral Fiber (Fiberglass) Preformed Pipe, Type I or Pipe and Tank Insulation for 14" and Larger Pipe Size	Less than 1	1.5	3.0	ASJ or ASJ-SSL	Indoor: N/A Outdoor: Aluminum with Moisture Barrier
		1 to Less than 1.5	1.5	3.0		Indoor: N/A Outdoor: Aluminum with Moisture Barrier
		1.5 to Less than 4	2.0	4.0		Indoor: N/A Outdoor: Aluminum with Moisture Barrier
		4 to Less than 8	2.0	4.0		Indoor: N/A Outdoor: Aluminum with Moisture Barrier
		8 and Larger	2.0	4.0		Indoor: N/A Outdoor: Aluminum with Moisture Barrier

Heating Hot Water Systems: 85 deg F to 140 deg F						
Insulation Conductivity Btu-in/hr-deg F-SF at Mean Temp (deg F)	Insulation Type	Pipe Size (inch)	Indoor - Minimum Thickness (inch)	Outdoor Minimum Thickness (inch)	Factory Applied Jacket	Field Applied Jacket
0.22 to 0.28 at 100	Mineral Fiber (Fiberglass)	Less than 1	1.0	2.0	ASJ or ASJ-SSL	Indoor: N/A Outdoor: Aluminum with Moisture Barrier

	Preformed Pipe, Type I or Pipe and Tank Insulation for 14" and Larger Pipe Size	1 to Less than 1.5	1.0	2.0		Indoor: N/A
						Outdoor: Aluminum with Moisture Barrier
		1.5" to Less than 4	1.5	3.0		Indoor: N/A
						Outdoor: Aluminum with Moisture Barrier
		4 to Less than 8	1.5	3.0		Indoor: N/A
						Outdoor: Aluminum with Moisture Barrier
		8 and Larger	1.5	3.0		Indoor: N/A
						Outdoor: Aluminum with Moisture Barrier

Cooling and Glycol Energy Recovery Systems: Below 40 deg F Applies to the Following Systems: Chilled Water, Refrigerant, Brine, Glycol Energy Recovery Systems (winter mode), Cooling Tower Piping When Used for Winter Free Cooling and All Outdoor Heat Traced Piping						
Insulation Conductivity Btu-in/hr-deg F-SF at Mean Temp (deg F)	Insulation Type	Pipe Size (inch)	Indoor - Minimum Thickness (inch)	Outdoor Minimum Thickness (inch)	Factory Applied Jacket	Field Applied Jacket
0.20 to 0.26 at 50	Mineral Fiber (Fiberglass) Preformed Pipe, Type I or Pipe and Tank Insulation for 14" and Larger Pipe Size	Less than 1	1.5	3.0	ASJ or ASJ-SSL	Indoor: N/A
						Outdoor: Aluminum with Moisture Barrier
		1 to Less than 1.5	1.5	3.0		Indoor: N/A
						Outdoor: Aluminum with Moisture Barrier
		1.5 to Less than 4	1.5	3.0		Indoor: N/A
						Outdoor: Aluminum with Moisture Barrier
		4 to Less than 8	1.5	3.0		Indoor: N/A
						Outdoor: Aluminum with Moisture Barrier
		8 and Larger	1.5	3.0		Indoor: N/A
						Outdoor: Aluminum with Moisture Barrier

Cooling and Glycol Energy Recovery Systems: 40 deg F to 65 deg F Applies to the Following Systems: Chilled Water, Refrigerant, Brine, Glycol Energy Recovery Systems (winter mode), Cooling Tower Piping When Used for Winter Free Cooling and All Outdoor Heat Traced Piping						
Insulation Conductivity Btu-in/hr-deg F-SF at Mean Temp (deg F)	Insulation Type	Pipe Size (inch)	Indoor - Minimum Thickness (inch)	Outdoor Minimum Thickness (inch)	Factory Applied Jacket	Field Applied Jacket
0.21 to 0.27 at 75	Mineral Fiber (Fiberglass) Preformed Pipe, Type I or Pipe and Tank Insulation for 14" and Larger Pipe Size	Less than 1	1.5	3.0	ASJ or ASJ-SSL	Indoor: N/A
						Outdoor: Aluminum with Moisture Barrier
		1 to Less than 1.5	1.5	3.0		Indoor: N/A
						Outdoor: Aluminum with Moisture Barrier
		1.5 to Less than 4	1.5	3.0		Indoor: N/A
						Outdoor: Aluminum with Moisture Barrier

		4 to Less than 8	1.5	3.0		Indoor: N/A Outdoor: Aluminum with Moisture Barrier
		8 and Larger	1.5	3.0		Indoor: N/A Outdoor: Aluminum with Moisture Barrier

Cooling Coil Condensate Piping, Outdoor Cooling Tower Makeup Water Piping and Equipment Drain Piping: All						
Insulation Conductivity Btu-in/hr-deg F-SF at Mean Temp (deg F)	Insulation Type	Pipe Size (inch)	Indoor - Minimum Thickness (inch)	Outdoor Minimum Thickness (inch)	Factory Applied Jacket	Field Applied Jacket
Mineral Fiber with Conductivity = 0.20 to 0.26 at 50 Flexible Elastomeric with Conductivity = 0.26 at 0 (2013 ASHRAE Fundamentals Handbook)	Mineral Fiber (Fiberglass) Preformed Pipe, Type I or Flexible Elastomeric	Less than 1	0.75	2	ASJ or ASJ-SSL for Mineral Fiber N/A for Flexible Elastomeric	Indoor: N/A Outdoor: Mineral Fiber: Aluminum with Moisture Barrier; Flexible Elastomeric: Glass-Fiber Cloth
		1 to Less than 1.5	0.75	2		Indoor: N/A Outdoor: Mineral Fiber: Aluminum with Moisture Barrier; Flexible Elastomeric: Glass-Fiber Cloth
		1.5 to Less than 4	0.75	2		Indoor: N/A Outdoor: Mineral Fiber: Aluminum with Moisture Barrier; Flexible Elastomeric: Glass-Fiber Cloth
		4 to Less than 8	0.75	2		Indoor: N/A Outdoor: Mineral Fiber: Aluminum with Moisture Barrier; Flexible Elastomeric: Glass-Fiber Cloth
		8 and Larger	0.75	2		Indoor: N/A Outdoor: Mineral Fiber: Aluminum with Moisture Barrier; Flexible Elastomeric: Glass-Fiber Cloth

Air Conditioning System Refrigerant Suction, Outdoor Liquid Line and Hot Gas Piping: All Minimum Pipe Operating Temperature 40 deg F

Insulation Conductivity Btu-in/hr-deg F-SF at Mean Temp (deg F)	Insulation Type	Pipe Size (inch)	Indoor - Minimum Thickness (inch)	Outdoor Minimum Thickness (inch)	Factory Applied Jacket	Field Applied Jacket
0.26 at 0 (2013 ASHRAE Fundamentals Handbook)	Flexible Elastomeric	Less than 3	1.5	1.5	N/A	Indoor: N/A Outdoor: Glass-Fiber Cloth
		3 to 4	1.5	2.0		Indoor: N/A Outdoor: Glass-Fiber Cloth
		6 to 8	1.5	2.5		Indoor: N/A Outdoor: Glass-Fiber Cloth
		10 to 14	1.5	3.0		Indoor: N/A Outdoor: Glass-Fiber Cloth
		16 to 24	1.5	3.5		Indoor: N/A Outdoor: Glass-Fiber Cloth

3.15 OUTDOOR, UNDERGROUND PIPING INSULATION SCHEDULE

A. This section does not apply where other Division 23 sections require the installation of loose-fill insulation for underground piping.

B. Schedule of field installed insulation for underground piping:

System Served	Insulation Type	Minimum Insulation Thickness (inches)
Chilled Water, Condenser Water, Heating Hot Water 200 deg F and Below, Dual Temperature (Heating/Cooling) Piping, All Sizes	Cellular Glass with Underground Direct-Buried Piping Jacket	2.0
Heating Hot Water All Sizes Above 200 deg F, All Sizes		3.0
Steam and Steam Condensate All Sizes, 140 psig/350 deg F and Below, All Sizes		4.0
Steam and Steam Condensate All Sizes, 141 psig and Above/351 deg F and Above, All Sizes		5.0
Heated Fuel Oil Piping, All Sizes		2.0

3.16 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Piping, Concealed:

1. None.

2. Aluminum, Smooth, Corrugated: 0.024 inch thick.
3. Painted Aluminum, Smooth, Corrugated 0.024 inch thick.
4. Stainless Steel, Type 304, Smooth 2B Finish or Corrugated: 0.024 inch thick.

D. Piping, Exposed:
1. Painted Aluminum, Smooth, Corrugated with Z-Shaped Locking Seam: 0.024 inch thick.
2. Stainless Steel, Type 304, Smooth 2B Finish or Corrugated with Z-Shaped Locking Seam: 0.024 inch thick.

3.17 UNDERGROUND, FIELD-INSTALLED INSULATION JACKET

A. For underground direct-buried piping applications, install underground direct-buried jacket over insulation material.

END OF SECTION

SECTION 230800
COMMISSIONING OF HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes commissioning process requirements for HVAC&R systems, assemblies, and equipment. B. Related Sections:

1. Division 01 "General Commissioning Requirements" for general commissioning process requirements.

1.3 DEFINITIONS

A. Commissioning Plan: A document that outlines the organization, schedule, allocation of resources, and documentation requirements of the commissioning process.

B. CxA: Commissioning Authority.

C. HVAC&R: Heating, Ventilating, Air Conditioning, and Refrigeration.

D. Systems, Subsystems, Equipment, and Components: Where these terms are used together or separately, they shall mean "as-built" systems, subsystems, equipment, and components.

1.4 INFORMATIONAL SUBMITTALS

A. Certificates of readiness.

B. Certificates of completion of installation, prestart, and startup activities.

1.5 ALLOWANCES

A. Labor, instrumentation, tools, and equipment costs for technicians for the performance of commissioning testing are covered by the "Schedule of Allowances" Article in Division 01 "Allowances."

1.6 UNIT PRICES

A. Commissioning testing allowance may be adjusted up or down by the "List of Unit Prices" Article in Division 01 "Unit Prices" when actual man-hours are computed at the end of commissioning testing.

1.7 CONTRACTOR'S RESPONSIBILITIES

A. Perform commissioning tests at the direction of the CxA.

B. Attend construction phase controls coordination meeting.

C. Attend testing, adjusting, and balancing review and coordination meeting.

D. Participate in HVAC&R systems, assemblies, equipment, and component maintenance orientation and inspection as directed by the CxA.

E. Provide information requested by the CxA for final commissioning documentation.

F. Provide measuring instruments and logging devices to record test data, and provide data acquisition equipment to record data for the complete range of testing for the required test period.

1.8 CXA'S RESPONSIBILITIES

A. Provide Project-specific construction checklists and commissioning process test procedures for actual HVAC&R systems, assemblies, equipment, and components to be furnished and installed as part of the construction contract. B. Direct commissioning testing.

C. Verify testing, adjusting, and balancing of Work are complete.

D. Provide test data, inspection reports, and certificates in Systems Manual.

1.9 COMMISSIONING DOCUMENTATION

A. Provide the following information to the CxA for inclusion in the commissioning plan:

1. Plan for delivery and review of submittals, systems manuals, and other documents and reports.
2. Identification of installed systems, assemblies, equipment, and components including design changes that occurred during the construction phase.
3. Process and schedule for completing construction checklists and manufacturer's prestart and startup checklists for HVAC&R systems, assemblies, equipment, and components to be verified and tested.
4. Certificate of completion certifying that installation, prestart checks, and startup procedures have been completed.
5. Certificate of readiness certifying that HVAC&R systems, subsystems, equipment, and associated controls are ready for testing.
6. Test and inspection reports and certificates.
7. Corrective action documents.
8. Verification of testing, adjusting, and balancing reports.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 TESTING PREPARATION

A. Certify that HVAC&R systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.

B. Certify that HVAC&R instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents, and that pretest set points have been recorded.

C. Certify that testing, adjusting, and balancing procedures have been completed and that testing, adjusting, and balancing reports have been submitted, discrepancies corrected, and corrective work approved.

D. Set systems, subsystems, and equipment into operating mode to be tested (e.g., normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).

E. Inspect and verify the position of each device and interlock identified on checklists.

F. Check safety cutouts, alarms, and interlocks with smoke control and life-safety systems during each mode of operation.

G. Testing Instrumentation: Install measuring instruments and logging devices to record test data as directed by the CxA.

3.2 TESTING AND BALANCING VERIFICATION

A. Prior to performance of testing and balancing Work, provide copies of reports, sample forms, checklists, and certificates to the CxA.

B. Notify the CxA at least 10 days in advance of testing and balancing Work, and provide access for the CxA to witness testing and balancing Work.

C. Provide technicians, instrumentation, and tools to verify testing and balancing of HVAC&R systems at the direction of the CxA.

1. The CxA will notify testing and balancing Subcontractor 10 days in advance of the date of field verification. Notice will not include data points to be verified.
2. The testing and balancing Subcontractor shall use the same instruments (by model and serial number) that were used when original data were collected.
3. Failure of an item includes, other than sound, a deviation of more than 10 percent. Failure of more than 10 percent of selected items shall result in rejection of final testing, adjusting, and balancing report. For sound pressure readings, a deviation of 3 dB shall result in rejection of final testing. Variations in background noise must be considered.
4. Remedy the deficiency and notify the CxA so verification of failed portions can be performed.

3.3 GENERAL TESTING REQUIREMENTS

A. Provide technicians, instrumentation, and tools to perform commissioning test at the direction of the CxA.

B. Scope of HVAC&R testing shall include entire HVAC&R installation, from central equipment for heat generation and refrigeration through distribution systems to each conditioned space. Testing shall include measuring capacities and effectiveness of operational and control functions.

C. Test all operating modes, interlocks, control responses, and responses to abnormal or emergency conditions, and verify proper response of building automation system controllers and sensors.

D. The CxA along with the HVAC&R Subcontractor, testing and balancing Subcontractor, and HVAC&R Instrumentation and Control Subcontractor shall prepare detailed testing plans, procedures, and checklists for HVAC&R systems, subsystems, and equipment.

E. Tests will be performed using design conditions whenever possible.

F. Simulated conditions may need to be imposed using an artificial load when it is not practical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by the CxA and document simulated conditions and methods of simulation. After tests, return settings to normal operating conditions.

G. The CxA may direct that set points be altered when simulating conditions is not practical.

H. The CxA may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are not practical.

I. If tests cannot be completed because of a deficiency outside the scope of the HVAC&R system, document the deficiency and report it to the Owner. After deficiencies are resolved, reschedule tests.

J. If the testing plan indicates specific seasonal testing, complete appropriate initial performance tests and documentation and schedule seasonal tests.

3.4 HVAC&R SYSTEMS, SUBSYSTEMS, AND EQUIPMENT TESTING PROCEDURES

A. Boiler Testing and Acceptance Procedures: Testing requirements are specified in HVAC boiler Sections. Provide submittals, test data, inspector record, and boiler certification to the CxA.

B. HVAC&R Instrumentation and Control System Testing: Field testing plans and testing requirements are specified in Division 23, Instrumentation and Control for HVAC and Division 23, Sequence and Operations for HVAC Controls. Assist the CxA with preparation of testing plans.

C. Pipe system cleaning, flushing, hydrostatic tests, and chemical treatment requirements are specified in HVAC piping Sections. HVAC&R Subcontractor shall prepare a pipe system cleaning, flushing, and hydrostatic testing plan. Provide cleaning, flushing, testing, and treating plan and final reports to the CxA. Plan shall include the following:

1. Sequence of testing and testing procedures for each section of pipe to be tested, identified by pipe zone or sector identification marker. Markers shall be keyed to Drawings for each pipe sector, showing the physical location of each designated pipe test section. Drawings keyed to pipe zones or sectors shall be formatted to allow each section of piping to be physically located and identified when referred to in pipe system cleaning, flushing, hydrostatic testing, and chemical treatment plan.

2. Description of equipment for flushing operations.
3. Minimum flushing water velocity.
4. Tracking checklist for managing and ensuring that all pipe sections have been cleaned, flushed, hydrostatically tested, and chemically treated.

D. Energy Supply System Testing: Provide technicians, instrumentation, tools, and equipment to test performance of steam and hot-water systems and equipment at the direction of the CxA. The CxA shall determine the sequence of testing and testing procedures for each equipment item and pipe section to be tested.

E. Refrigeration System Testing: Provide technicians, instrumentation, tools, and equipment to test performance of chillers, cooling towers, refrigerant compressors and condensers, heat pumps, and other refrigeration systems. The CxA shall determine the sequence of testing and testing procedures for each equipment item and pipe section to be tested.

F. HVAC&R Distribution System Testing: Provide technicians, instrumentation, tools, and equipment to test performance of air, steam, and hydronic distribution systems; special exhaust; and other distribution systems, including HVAC&R terminal equipment and unitary equipment.

G. Vibration and Sound Tests: Provide technicians, instrumentation, tools, and equipment to test performance of vibration isolation and seismic controls.

END OF SECTION

SECTION 230900
INSTRUMENTATION AND CONTROL FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes control equipment for HVAC systems and components, including control components for terminal heating and cooling units not supplied with factory-wired controls.

1.3 DEFINITIONS

A. DDC: Direct digital control.

B. I/O: Input/output.

C. LonWorks: A control network technology platform for designing and implementing interoperable control devices and networks. D. MS/TP: Master slave/token passing.

E. PC: Personal computer.

F. PID: Proportional plus integral plus derivative.

G. RTD: Resistance temperature detector.

H. AHU: Air Handling Unit.

I. BMS: Building Management System.

J. CFM: Cubic Feet per Minute. K. DDC: Direct-digital controls.

L. FAS: Fire Alarm System.

M. HVAC: Heating, Ventilating and Air Conditioning.

N. LAN: Local area network.

O. LCD: Liquid Crystal Display

P. MER: Mechanical Equipment Room.

Q. PID: Proportional Integral Derivative.

R. POT: Portable Operators Terminal.

S. RAHU: Rooftop Air Handling Unit.

T. VAV: Variable air volume.

U. VFD: Variable Frequency Drive.

1.4 SYSTEM PERFORMANCE

A. Comply with the following performance requirements:

1. Graphic Display: Display graphic with minimum 20 dynamic points with current data within 10 seconds.

2. Graphic Refresh: Update graphic with minimum 20 dynamic points with current data within 8 seconds.

3. Object Command: Reaction time of less than two seconds between operator command of a binary object and device reaction.

4. Object Scan: Transmit change of state and change of analog values to control units or workstation within six seconds.

5. Alarm Response Time: Annunciate alarm at workstation within 45 seconds. Multiple workstations must receive alarms within five seconds of each other.

6. Program Execution Frequency: Run capability of applications as often as five seconds, but selected consistent with mechanical process under control.

7. Performance: Programmable controllers shall execute DDC PID control loops, and scan and update process values and outputs at least once per second.

8. Reporting Accuracy and Stability of Control: Report values and maintain measured variables within tolerances as follows:

a. Water Temperature: Plus or minus 1 deg F.

b. Water Flow: Plus or minus 5 percent of full scale.

c. Water Pressure: Plus or minus 2 percent of full scale.

d. Space Temperature: Plus or minus 1 deg F.

e. Ducted Air Temperature: Plus or minus 1 deg F.

f. Outside Air Temperature: Plus or minus 2 deg F.

g. Dew Point Temperature: Plus or minus 3 deg F.

h. Temperature Differential: Plus or minus 0.25 deg F.

i. Relative Humidity: Plus or minus 5 percent.

j. Airflow (Pressurized Spaces): Plus or minus 3 percent of full scale.

k. Airflow (Measuring Stations): Plus or minus 5 percent of full scale.

l. Airflow (Terminal): Plus or minus 10 percent of full scale.

m. Air Pressure (Space): Plus or minus 0.01-inch wg.

n. Air Pressure (Ducts): Plus or minus 0.1-inch wg.

o. Carbon Monoxide: Plus or minus 5 percent of reading.

p. Carbon Dioxide: Plus or minus 50 ppm.

q. Electrical: Plus or minus 5 percent of reading.

1.5 WORK INCLUDED

A. Furnish an extension to the existing Albireo Energy RUMC campus wide BMS in accordance with this specification section. This includes all supervisory controllers, network controllers, logic controllers and all input/output devices. Items of work included are as follows:

1. Provide a submittal that meets the requirements below for approval.
2. Coordinate installation schedule with the mechanical contractor and general contractor.
3. Provide installation of all panels and devices unless otherwise stated.
4. The BMS Contractor shall provide power for panels, control devices, **and butterfly valves** from a source designated by the electrical contractor. This includes power for all primary and secondary controllers, control valves, etc. Coordinate with Electrical for the available sources. VAV box controllers shall be powered directly by the base electrician with 120V.
5. Provide all low voltage control wiring for the DDC system.
6. Provide miscellaneous control wiring for HVAC and related systems regardless of voltage.
7. Provide engineering and technician labor to program and commission software for each system and operator interface. Submit commissioning reports for approval.
8. Provide testing, demonstration and training as specified below.
9. Provide all necessary BACnet-compliant hardware and software to meet the system’s functional specifications. Provide Protocol Implementation Conformance Statement (PICS) for Windows-based control software and every controller in system.
10. Provide BMS controls for all Laboratory HVAC Systems incorporating comfort control functions with safety/compliance information management functions completely and seamlessly integrated into the existing Albireo Energy DDC Building Management System. Completely and seamlessly integrated shall mean that all system points, regardless of whether they are Laboratory Control or BMS points types shall all be controlled and/or alarmed from the BMS Operator Workstations. All the same software capabilities and functionality provided with the DDC component of this system, including full featured graphical control and simultaneous multiple display dynamic graphing, shall be provided.

1.6 ACTION SUBMITTALS

A. Product Data: Include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, and installation and startup instructions for each type of product indicated.

1. DDC System Hardware: Bill of materials of equipment indicating quantity, manufacturer, and model number. Include technical data for operator workstation equipment, interface equipment, control units, transducers/transmitters, sensors, actuators, valves, relays/switches, control panels, and operator interface equipment.

2. Control System Software: Include technical data for operating system software, operator interface, color graphics, and other third-party applications.

3. Controlled Systems: Instrumentation list with element name, type of device, manufacturer, model number, and product data. Include written description of sequence of operation including schematic diagram.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Bill of materials of equipment indicating quantity, manufacturer, and model number.
2. Schematic flow diagrams showing fans, pumps, coils, dampers, valves, and control devices.
3. Wiring Diagrams: Power, signal, and control wiring.
4. Details of control panel faces, including controls, instruments, and labeling.
5. Written description of sequence of operation.
6. Schedule of dampers including size, leakage, and flow characteristics.
7. Schedule of valves including flow characteristics.
8. DDC System Hardware:
    a. Wiring diagrams for control units with termination numbers.
    b. Schematic diagrams and floor plans for field sensors and control hardware.
    c. Schematic diagrams for control, communication, and power wiring, showing trunk data conductors and wiring between operator workstation and control unit locations.
9. Control System Software: List of color graphics indicating monitored systems, data (connected and calculated) point addresses, output schedule, and operator notations.
10. Controlled Systems:
    a. Schematic diagrams of each controlled system with control points labeled and control elements graphically shown, with wiring.
    b. Scaled drawings showing mounting, routing, and wiring of elements including bases and special construction.
    c. Written description of sequence of operation including schematic diagram.
    d. Points list.

1.7 INFORMATIONAL SUBMITTALS

A. Data Communications Protocol Certificates: Certify that each proposed DDC system component complies with ASHRAE 135.

B. Data Communications Protocol Certificates: Certify that each proposed DDC system component complies with LonWorks.

C. Qualification Data: For [**Installer**] [**and**] [**manufacturer**].

D. Software Upgrade Kit: For Owner to use in modifying software to suit future systems revisions or monitoring and control revisions. E. Field quality-control test reports.

1.8 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For HVAC instrumentation and control system to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01, Operation and Maintenance Data, include the following:

1. Maintenance instructions and lists of spare parts for each type of control device and compressed-air station.
2. Interconnection wiring diagrams with identified and numbered system components and devices.
3. Keyboard illustrations and step-by-step procedures indexed for each operator function.
4. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
5. Calibration records and list of set points.

B. Software and Firmware Operational Documentation: Include the following:

1. Software operating and upgrade manuals.
2. Program Software Backup: On a magnetic media or compact disc, complete with data files.
3. Device address list.
4. Printout of software application and graphic screens.
5. Software license required by and installed for DDC workstations and control systems.

1.9 QUALITY ASSURANCE

A. Installer Qualifications: Automatic control system manufacturer's authorized representative who is trained and approved for installation of system components required for this Project.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with ASHRAE 135 for DDC system components.

1.10 DELIVERY, STORAGE, AND HANDLING

A. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to equipment manufacturer.

B. System Software: Update to latest version of software at Project completion.

1.11 COORDINATION

A. Coordinate location of thermostats, humidistats, and other exposed control sensors with plans and room details before installation.

B. Coordinate equipment with Division 26, Motor-Control Centers to achieve compatibility with motor starters and annunciation devices.

C. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03, Cast-in-Place Concrete.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.

2.2 CONTROL SYSTEM

1. Only Acceptable BMS Product/Vendor- Existing RUMC Campus BMS Vendor– EcoStuxure by Albireo Energy- Contact Anthony Nobile (732-407-6082)

B. Control system shall consist of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, accessories, and software connected to distributed controllers operating in multiuser, multitasking environment on token-passing network and programmed to control mechanical systems. An operator workstation permits interface with the network via dynamic color graphics with each mechanical system, building floor plan, and control device depicted by point-and-click graphics.

C. Furnish an extension to the existing RUMC Campus BACnet-based BMS system, based on a distributed control system in accordance with this specification. The operator's workstation, all controllers and all input/output devices shall communicate using the protocols and network standards as defined by ANSI/ASHRAE Standard 135 - 2004 - BACnet. In other words, all workstations and controllers shall be BACnet devices. No gateways shall be used for communication to controllers installed under this section. Gateways may be used for communication to existing systems or to systems installed under other sections. Use of proprietary protocol on any part of the network is prohibited.

D. Provide Building Controllers (BC), Advanced Application Controllers (AAC), Application Specific Controllers (ASC), Smart Actuators (SA) and Smart Sensors (SS) as required. Every device in the system which executes control logic and directly controls HVAC equipment must conform to a standard BACnet Device profile as specified in ANSI/ASHRAE 135-2004, BACnet Annex L. Unless otherwise specified, hardwired actuators and sensors may be used in lieu of BACnet Smart Actuators and Smart Sensors.

2.3 CONTROL PANELS

A. Fully enclosed, steel-rack-type cabinet with locking doors or locking removable backs. Match finish of panels and provide laminated as-built wiring diagrams, flow diagrams, etc. related to the system being controlled inside the associated cabinet. Each control panel shall be clearly and permanently labeled with the controller designation and indication of the mechanical equipment served.

B. Unitized cabinet with suitable brackets for wall or floor mounting, located adjacent to each system under automatic control. Provide common keying for all panels.

1. Fabricate panels of furniture-quality steel or extruded-aluminum alloy, totally enclosed, with hinged doors and keyed lock and with manufacturer's standard shop-painted finish. All panels shall have common keying. Provide NEMA 4 rating at a minimum or the appropriate NEMA rating for application.

2.4 BMS SYSTEM ARCHITECTURE

A. The BMS system shall use a Client/Server architecture based on a modular PC network, utilizing industry standard operating systems, networks and protocols.

B. The system shall allow the distribution of system functions such as monitoring and control and graphical user interface etc. across the network to achieve maximum flexibility and performance.

C. Data communications protocol shall be BACnet and shall comply with ASHRAE 135 - 2004.

2.5 BMS NETWORK

A. The design of the BMS shall network the existing RUMC BMS server or servers, personal computer operator workstations (if applicable), primary control panels and secondary control panels. The network architecture shall consist of multiple network levels. Provide a peer-to-peer Primary Network to connect the server, operator workstation(s) and all primary control panels in the building for global system operation. Provide secondary networks to connect from each primary control panel to the secondary control panels of associated terminal equipment.

B. Primary control panels may be connected to the primary network via routers if this follows the standard architecture of a specified manufacturer. Provide network or supervisory controllers if required according to manufacturer’s standard architecture layout to achieve network functionality. Quantity and locations of routers, network controllers, and supervisory controllers to be coordinated with Engineer.

C. Access to system data shall not be restricted by the hardware configuration of the BMS. The hardware configuration of the BMS network shall be totally transparent to the user when accessing data or developing control programs.

D. The BMS design shall allow the co-existence of current and future primary control panels and personal computer operator workstations on the same primary network.

E. Primary Peer-to-Peer Network

1. All operator workstations and primary controllers shall directly reside on a network such that communications (i.e., ability to access, edit, modify, add, delete, back up, report, trend, restore all system point database and all programs) may be executed directly between servers, primary control panels, and operator workstations on a peer-to-peer basis.
2. The primary network shall provide the following minimum performance:
    a. Provide high-speed data transfer rates for alarm reporting, quick report generation from multiple controllers and upload/download efficiency between network devices. System performance shall insure that an alarm occurring at any Control Panel is displayed at any PC workstation, standalone alarm printer and/or Control Panel within 5 seconds.
    b. Support of any combination of primary control panels and operator workstations directly connected to the primary network. A minimum of 64 devices and a maximum of 100 devices shall be supported on a single primary network.
    c. Message and alarm buffering to prevent information from being lost.
    d. Error detection, correction and re-transmission to guarantee data integrity.
    e. Synchronization of real-time clocks between server, primary control panels, and operator workstations, including automatic daylight savings time corrections.
    f. Provide network wiring as required to ensure total system operation and communication without interruption, even if the network wiring is open in one (1) location.
    g. The primary network shall allow the primary control panels to access any data from, or send control commands and alarm reports directly to, any other primary control panel or combination of controllers on the network without dependence upon a central or intermediate processing device. The primary control panel shall send alarm reports to multiple operator workstations without dependence upon a central or intermediate processing device. The peer-to-peer network shall also allow any primary control panel to access, edit, modify, add, delete, back up, restore all system point database and all programs.
    h. The primary network shall allow the primary control panels to assign password access and control priorities to each system individually. The logon password (at any PC workstation or portable operator terminal) shall enable the operator to monitor, adjust and control only the system that the operator is authorized for. All other systems shall not be displayed at the PC workstation or portable terminal. Passwords and priorities for every point shall be fully programmable and adjustable.
    i. Each personal computer operator workstation shall support hardwired and dial up type primary networks.

F. Secondary Network

1. This network shall connect and support stand-alone secondary control panels and shall communicate bi-directionally with the primary network through primary control panels for transmission of global data. A sufficient number of primary control panels shall be provided for connection of secondary networks based on quantity of secondary controls panels and distance limitations.

2. Secondary control panels shall be arranged on the secondary network in a functional relationship manner with the primary control panels. For example, a VAV secondary control panel on a secondary network of a primary control panel that is controlling the VAV's corresponding AHU.

3. A maximum of 100 secondary control panels may be configured on an individual secondary network to insure adequate global data and alarm response times and future space capacity.

4. The Secondary Network shall be connected to and communicate with the primary control panel independently.

2.6 UNINTERRUPTIBLE POWER SUPPLY

A. An Uninterruptible Power Supply (UPS) shall be provided and installed by the Contractor for each of the following devices that are powered by the BMS including; BMS primary control panel. Each UPS shall power the device for a minimum of 30 minutes, in the case of power interruption.

B. The UPS shall consist of a battery power source, charger, AC output inverter system and automatic load transfer circuits for a full automatic operation. The UPS shall be an on-line type. When normal AC power returns, the UPS shall transfer the load to the rectifier output. At this time, the charger shall turn on to its 'high' charge rate until the batteries are charged approximately 80% of their rated capacity and then automatically shall switch to its maintenance 'sensing' position to keep the batteries in their best full-charge condition. Battery recharge time shall not be more than 3 hours.

C. Each UPS shall be provided, as a minimum, with pilot lights for the following conditions: "Incoming AC Power is Available", "UPS Ready Mode" and "UPS in Standby Mode". The UPS shall have the capability to hot-swap batteries without interrupting the supply of power to its users.

D. The batteries shall be of the totally enclosed nickel-cadmium type or equal. Batteries that can leak gas shall not be acceptable. There shall not be any damages should the emergency outage of line power exceed the maximum operation time of the UPS. Automatic shutdown shall occur when the UPS' maximum duty cycle is exceeded.

E. Provide APC, Liebert, or pre-approved equal.

2.7 PRIMARY CONTROL PANEL HARDWARE

A. Provide one primary control panel as shown on drawings (AHUs, chillers, condensers, etc.)

B. ASHRAE 135 - 2012 Compliance: Primary control panels shall use BACnet/ASHRAE 135 - 2012 protocol and communicate using ISO 8802-3

(Ethernet) datalink/physical layer protocol.

C. Spare Capacity

1. All primary control panels shall be installed with 10% spare points (of each type) and 10% spare memory capacity for future connections. The type of spare point capacity shall be in the same proportion as the implemented I/O functions of the panel, but in no case shall there be less than two (2) spares of each implemented I/O type. Provide all hardware modules, software modules, processors, power supplies, communication controllers, etc. required to ensure adding a point to the spare point location only requires the addition of the appropriate sensor/actuator and field wiring/tubing.

2. Provide all processors, power supplies and communication controllers so that the implementation of adding a point to the spare point location only requires the addition of the appropriate:

a. Expansion modules.

b. Sensor/actuator.

c. Field wiring/tubing.

D. Provide all necessary hardware for a complete operating system as required. All hardware shall reside in each primary control panel. Primary control panels shall not be dependent upon any higher level computer or another controller for operation.

E. Each primary control panel shall, at a minimum, be provided with:

1. Appropriate NEMA rated metal enclosure.
2. An integral real-time clock.
3. A 32bit, stand-alone, multi-tasking, multi-user, real-time 48M Hz digital control microprocessor module.
4. Primary Network communication module, if needed for primary network communications.
5. Secondary Network communication module, if needed for secondary network communications.
6. Memory to accommodate all primary control panel software requirements, including but not limited to, its own operating system and databases, including control processes, energy management applications, alarm management applications, historical/trend data for points specified, maintenance support applications, custom processes, operator I/O, dial-up communications. Controller shall have a minimum of 32 MB RAM, 1 MB of flash, and 16K EPROM or EEPROM. Controller shall be provided with battery backup capable of supporting all RAM, clock functions, DDC database and operating programs within the controller for a minimum of 72 hours in the event of power failure or power interruption (if information is not stored in non-volatile memory).
7. Data collection/ Data Trend module sized for 10,000 data samples.
8. Power supplies as required for all associated modules, sensors, actuators, etc.
9. Software modules as required for all sequences of operation, logic sequences and energy management routines. Relay logic is not acceptable.

10. A portable operator terminal connection port to allow the temporary use of portable devices without interrupting the normal operation of permanently connected modems, printers or terminals.
11. Monitoring of all industry standard types of analog and digital inputs and outputs, without the addition of equipment to the primary control panel.
12. Auxiliary enclosure for analog output transducers, isolation relays, etc. Auxiliary enclosure shall be part of primary enclosure or mounted adjacent to the primary enclosure.
13. Local status indication for each digital input and output for constant, up-to-date verification of all point conditions without the need for an operator I/O device. Each primary control panel shall perform diagnostics on all inputs and outputs and a failure of any input or output shall be indicated both locally and at the operator workstation.

F. The operator shall have the ability to manually override automatic or centrally executed commands at the primary control panels via local, point discrete, on-board hand/off/auto operator override switches. If on board switches are not available, provide separate control panels with HOA switches. Mount panel adjacent to primary control panel. These override switches shall be operable whether the panel processor is operational or not. Provide HOA switch for each digital output, including spares. Provide hand/auto switch and gradual positioning potentiometer for each analog output, including spares.

G. Each primary control panel shall continuously perform self-diagnostics on all hardware modules and network communications. The primary control panel shall provide both local and remote annunciation of any detected component failures, or repeated failure to establish communication with any system.

H. All databases and programs shall be stored in non-volatile EEPROM, EPROM and PROM.

I. Each primary control panel shall support firmware upgrades without the need to replace hardware.

J. Primary control panels shall provide at least two (2) EIA-232C serial data communication ports for operation of operator I/O devices such as industry standard printers, operator terminals, modems and portable laptop operator's terminals. Primary control panels shall allow temporary use of portable devices without interrupting the normal operation of permanently connected modems, printers or terminals.

K. Immunity to power and noise.

1. Controller shall be able to operate at 90% – 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage.

2. Operation shall be protected against electrical noise of 5 – 120 Hz and from keyed radios up to 5W at 1m (3’).

3. Isolation shall be provided at all primary network terminations, as well as all field point terminations to suppress induced voltage transients consistent with:

a. RF-Conducted Immunity (RFCI) per ENV 50141 (IEC 1000-4-6) at 3V.
b. Electro Static Discharge (ESD) Immunity per EN 61000-4-2 (IEC 10004-2) at 8kV air discharge, 4kV contact.

c. Electrical Fast Transient (EFT) per EN 61000-4-4 (IEC 1000-4-4) at 500V signal, 1kV power.

d. Output Circuit Transients per UL 864 (2,400V, 10A, 1.2 Joule max).

4. Isolation shall be provided at all Primary Controller's AC input terminals to suppress induced voltage transients consistent with:

a. IEEE Standard 587 1980.

b. UL 864 Supply Line Transients.

c. Voltage Sags, Surge and Dropout per EN 61000-4-11 (EN 1000-4-11).

2.8 PRIMARY CONTROL PANEL SOFTWARE

A. Furnish the following applications software to form complete operating system for building and energy management as described in this specification.

B. Provide all necessary software for a complete operating system as required. All software shall reside in each primary control panel. Primary control panels shall not be dependent upon any higher level computer or another controller for operation.

C. All points, panels and programs shall be identified by a 30 character name and a 16 character point descriptor. The same names shall be displayed at both the primary control panel(s) (via portable terminal, printer or modem) and the PC operator workstation(s).

D. All digital points shall have a user-defined, 2-state status indication with 8 characters minimum (e.g., Summer, Enabled, Disabled, Abnormal).

E. System Security

1. User access shall be secured using individual security passwords and user names.
2. Passwords shall restrict the user to the objects, applications and system functions as assigned by the system manager.
3. Primary Controllers shall be able to assign a minimum of 50 passwords access and control priorities to each point individually. The logon password (at any Operator Interface or portable operator terminal) shall enable the operator to monitor, adjust and control only the points that the operator is authorized for. All other points shall not be displayed at the Operator Interface or portable terminal. Passwords and priorities for every point shall be fully programmable and adjustable.
4. User Log On / Log Off attempts shall be recorded.
5. The system shall protect itself from unauthorized use by automatically logging off following the last keystroke. The delay time shall be user-definable.

F. Each primary control panel shall, at a minimum, be provided with software for:

1. 2-position control, proportional control, proportional plus integral control, proportional, integral, plus derivative control algorithms, all with automatic control loop tuning.
2. Limiting the number of times each piece of equipment may be cycled within any 1-hour period.

3. The system shall provide protection against excessive demand situations during start-up periods by automatically introducing time delays between successive start commands to heavy electrical loads. Upon the resumption of power, each DDC Controller shall analyze the status of all controlled equipment, compare it with normal occupancy scheduling and turn equipment on or off as necessary to resume normal operations.
4. Priority load shedding (10 zones).
5. Energy management routines including time of day scheduling, calendar-based scheduling, holiday scheduling, temporary schedule overrides, start-stop time optimization, automatic daylight savings time switch over, night setback control, enthalpy switch over, peak demand limiting, temperature-compensated duty cycling, heating/ cooling interlock, supply temperature reset, priority load shedding and power failure restart.
6. Custom, job-specific processes defined by the user, to automatically perform calculations and special control routines and sequences of operations.
   a. Controllers shall be able to execute custom, job-specific processes defined by the user, to automatically perform calculations and special control routines.
   b. It shall be possible to use any system measured point data or status, any system calculated data, a result from any process or any user-defined constant in any controller in the system.
   c. Any process shall be able to issue commands to points in any and all other controllers in the system.
   d. Processes shall be able to generate operator messages and advisories to other operator I/O devices. A process shall be able to directly send a message to a specified device or cause the execution of a dial-up connection to a remote device such as a printer or pager.
   e. The custom control programming feature shall be documented via English language descriptors.
   f. Each controller shall support text comment lines in the operating program to allow for quick troubleshooting, documentation and historical summaries of program development.
   g. Controller shall provide a HELP function key, providing enhanced context sensitive on-line help with task orientated information from the user manual.
7. Generate and receive automatic and manual operator messages and advisories.
8. Comment lines for all programs.
9. Distributed independent alarm analysis and filtering. Reporting of selected alarms during system shutdown and start-up shall be automatically inhibited. A minimum of 6 priority levels shall be provided for each point.
10. Automatically accumulate and store run-time hours for all digital points.

11. Automatically sample, calculate and store consumption totals on a daily, weekly or monthly basis for all analog and pulse input type points.

G. Trend data shall be stored at the primary control panels and automatically uploaded to the PC workstation. Uploads shall occur based on user-defined intervals, manual commands, or automatically when the trend buffer is 80% full.

All trend data shall be available for use in any 3rd party personal computer applications located in the BMS.

H. Primary control panels shall be able to assign password access and control priorities to each system individually. The logon password (at any PC workstation(s) or POT) shall enable the operator to monitor, adjust and/or control only the systems, programs, primary control panel and/or secondary control panels that the operator is authorized for. All other systems, programs, primary and secondary control panels shall not be displayed at the PC workstation, POT or modem. Passwords and priority levels for each system, program, primary control panel and secondary control panel shall be fully programmable and adjustable.

I. Primary control panels shall be able to access any data from, or send control commands and alarm reports directly to, any other primary control panel or combination of controllers on the network without dependence upon a central or intermediate processing device. Primary control panels shall also be able to send alarm reports to multiple operator workstations without dependence upon a central or intermediate processing device.

J. Alarm management shall be provided to monitor and direct alarm information to operator devices. Each DDC Controller shall perform distributed, independent alarm analysis and filtering to minimize operator interruptions due to non-critical alarms, minimize network traffic and prevent alarms from being lost. At no time shall the DDC Controllers ability to report alarms be affected by either operator or activity at a PC workstation, local I/O device or communications with other panels on the network.

1. All alarm or point change reports shall include the point's English language description and the time and date of occurrence.
2. The user shall be able to define the specific system reaction for each point. Alarms shall be prioritized to minimize nuisance reporting and to speed operator response to critical alarms. A minimum of 6 priority levels shall be provided for each point. Point priority levels shall be combined with user definable destination categories (PC, printer, DDC Controller, etc.) to provide full flexibility in defining the handling of system alarms. Each DDC Controller shall automatically inhibit the reporting of selected alarms during system shutdown and start-up. Users shall have the ability to manually inhibit alarm reporting for each point.
3. Alarm reports and messages shall be routed to user-defined list of operator workstations or other devices based on time and other conditions. An alarm shall be able to start programs, print, be logged in the event log, generate custom messages and display graphics.

4. In addition to the point's descriptor and the time and date, the user shall be able to print, display or store a 200 character alarm message to more fully describe the alarm condition or direct operator response.
    a. Each DDC Controller shall be capable of storing a library of at least 50 alarm messages. Each message may be assignable to any number of points in the Controller.

5. Operator-selected alarms shall be capable of initiating a call to a remote operator device.

K. Scheduling:

1. Provide a comprehensive menu driven program to automatically start and stop designated object or group of objects in the system according to a stored time.
2. It shall be possible to define a group of objects as a custom event (i.e., meeting, athletic activity, etc.). Events can then be scheduled to operate all necessary equipment automatically.
3. For points assigned to one (1) common load group, it shall be possible to assign variable time delays between each successive start and stop within that group.
4. The operator shall be able to define the following information:
    a. Time, day.
    b. Commands such as on, off, auto and so forth.
    c. Time delays between successive commands.
    d. There shall be provisions for manual overriding of each schedule by an appropriate operator.
5. It shall be possible to schedule calendar-based events up to 1 year in advance based on the following:
    a. Weekly Schedule. Provide separate schedules for each day of the week. Each of these schedules should include the capability for start, stop, optimal start, optimal stop and night economizer. When a group of objects are scheduled together as an Event, provide the capability to adjust the start and stop times for each member.
    b. Exception Schedules. Provide the ability for the operator to designate any day of the year as an exception schedule. Exception schedules may be defined up to a year in advance. Once an exception schedule is executed, it will be discarded and replaced by the standard schedule for that day of the week.
    c. Holiday Schedules. Provide the capability for the operator to define up to 99 special or holiday schedules. These schedules may be placed on the scheduling calendar and will be repeated each year. The operator shall be able to define the length of each holiday period. L. Temperature-compensated duty cycling.

1. The DCCP (Duty Cycle Control Program) shall periodically stop and start loads according to various patterns.

2. The loads shall be cycled such that there is a net reduction in both the electrical demands and the energy consumed.

M. Automatic Daylight Savings Time Switchover: The system shall provide automatic time adjustment for switching to/from Daylight Savings Time.

N. Night setback control. The system shall provide the ability to automatically adjust setpoints for night control.

O. Enthalpy switchover (economizer). The Primary Controller Software shall control the position of the air handler relief, return and outside air dampers. If the outside air dry bulb temperature falls below changeover set point the software will modulate the dampers to provide 100% outside air. The user will be able to quickly changeover to an economizer system based on dry bulb temperature and will be able to override the economizer cycle and return to minimum outside air operation at any time.

P. PID Control. A PID (proportional-integral-derivative) algorithm with direct or reverse action and anti-windup shall be supplied. The algorithm shall calculate a time-varying analog value that is used to position an output or stage a series of outputs. The controlled variable, set point and PID gains shall be user-selectable.

Q. Sequencing. Provide application software based upon the sequences of operation specified to properly sequence equipment. R. Staggered Start:

1. This application shall prevent all controlled equipment from simultaneously restarting after a power outage. The order, in which equipment (or groups of equipment) is started, along with the time delay between starts, shall be user definable.

2. Upon the resumption of power, each Primary Controller shall analyze the status of all controlled equipment, compare it with normal occupancy scheduling and turn equipment on or off as necessary to resume normal operations. S. Totalization:

1. Run-Time Totalization. Primary Controllers shall automatically accumulate and store runtime hours for all digital input and output points. A high runtime alarm shall be assigned, if required, by the operator.

2. Consumption totalization. Primary Controllers shall automatically sample, calculate and store consumption totals on a daily, weekly or monthly basis for all analog and digital pulse input type points.

3. Event totalization. Primary Controllers shall have the ability to count events such as the number of times a pump or fan system is cycled on and off. Event totalization shall be performed on a daily, weekly or monthly basis for all points. The event totalization feature shall be able to store the records associated with events before reset.

T. A variety of historical data collection utilities shall be provided to manually or automatically sample, store and display system data for all points.

1. DDC Controllers shall store point history data for selected analog and digital inputs and outputs:

a. Any point, physical or calculated may be designated for trending. Any point, regardless of physical location in the network, may be collected and stored in each DDC Controllers point group. Two (2) methods of collection shall be allowed: either by a pre-defined time interval or upon a pre-defined change of value. Sample intervals of l minute to 7 days shall be provided. Each DDC Controller shall have a dedicated RAM-based buffer for trend data and shall be capable of storing a minimum of 10,000 data samples.

b. Trend data shall be stored at the DDC Controllers and automatically uploaded to the workstation. Uploads shall occur based upon user-defined interval, manual command or automatically when the trend buffers are 80% full. All trend data shall be available for use in any third party personal computer applications located on the MLN.

c. DDC Controllers shall also provide high resolution sampling capability for verification of control loop performance. Operator-initiated automatic and manual loop tuning algorithms shall be provided for a minimum of 36 operator-selected PID control loops. Provide capability to view or print trend and tuning reports.

(1) The controller shall perform a step response test with a minimum 1-second resolution, evaluate the trend data, calculate the new PID gains and input these values into the selected LOOP statement.

(2) Loop tuning shall be capable of being initiated either locally at the DDC Controller, from a network workstation, or remotely using dial-in modems. For all loop tuning functions, access shall be limited to authorized personnel through password protection.

U. DDC Controllers shall automatically accumulate and store run-time hours for all digital input and output points.

V. DDC Controllers shall automatically sample, calculate and store consumption totals on a daily, weekly, or monthly basis for all analog and digital pulse input type points.

W. DDC Controllers shall count events such as the number of times a pump or fan system is cycled on and off. Event totalization shall be performed on a daily, weekly and monthly basis for all points. The event totalization feature shall be able to store the records associated with a minimum of 9,999.9 events before reset.

2.9 SECONDARY CONTROL PANEL HARDWARE

A. ASHRAE 135 - 2012 Compliance: Secondary control panels shall use BACnet/ASHRAE 135 - 2012 protocol over MS/TP or BACnet IP.

B. Each secondary control panel shall operate as a stand-alone controller capable of performing its user selectable control routines independently of any other controller in the system. Each secondary control panel shall be a microprocessor-based, multi-tasking, real-time digital control processor.

C. Each Primary Controller shall be able to communicate with secondary controllers over the Secondary Network to control terminal equipment only.

D. Each secondary controller shall include all point inputs and outputs necessary to perform the specified control sequences. The secondary controller shall accept input and provide output signals that comply with industry standards. Controllers utilizing proprietary control signals shall not be acceptable. Outputs may be utilized either for 2-state, modulating, floating or proportional control, allowing for additional system flexibility.

E. Provide a secondary control panel for each of the following types of equipment (if applicable):

1. Exhaust Fans.
2. Room Pressurization.
3. Variable Air Volume (VAV) Boxes with Hot Water Reheat.
4. HEPA Filters
5. Other terminal equipment.
6. Note: It is acceptable to control multiple items mentioned above from a single secondary controller.

F. Each secondary control panel shall, at a minimum, be provided with:

1. Appropriate NEMA rated enclosure.
2. A stand-alone real-time digital control microprocessor module.
3. Secondary network communications ability.
4. Power supplies as required for all associated modules, sensors, actuators, etc.
5. Input/output points as required.
6. Software as required for all sequences of operation, logic sequences and energy management routines. Relay logic is not acceptable.
7. A portable operator terminal connection port.
8. Auxiliary enclosure for analog output transducers, isolation relays, etc. Auxiliary enclosure shall be part of primary enclosure or mounted adjacent primary enclosure.
9. Local LED status indication for each digital input and output.
10. Each controller measuring air volume shall include a differential pressure transducer.
11. SCR control of electric heaters.
12. Fan speed controller for fan powered VAV boxes.
13. Fan relay for fan powered VAV boxes and fan coil units.

G. Communication. Each controller shall perform its primary control function independent of other Secondary Network communication or if Secondary Network communication is interrupted. Reversion to a fail-safe mode of operation during Secondary Network interruption is not acceptable.

H. Control Algorithms. The controller shall receive its real-time data from the Primary Controller time clock to insure Secondary Network continuity. Each controller shall include algorithms incorporating proportional, integral and derivative (PID) gains for all applications. All PID gains and biases shall be fieldadjustable by the user via room sensor LCD or the portable operator's terminal as specified herein. Controllers that incorporate proportional and integral (PI) control algorithms only shall not be acceptable.

I. Control Applications. Operating programs shall be field-selectable for specific applications. In addition, specific applications may be modified to meet the user's exact control strategy requirements, allowing for additional system flexibility. Controllers that require factory changes of all applications are not acceptable.

J. Calibration. Each controller shall include provisions for manual and automatic calibration of the differential pressure transducer in order to maintain stable control and insuring against drift over time.

1. Manual calibration may be accomplished by either commanding the actuator to 0% via the POT or by depressing the room sensor override switch. Calibration of the transducer at the controller location shall not be necessary.

K. Each secondary control panel shall continuously perform self-diagnostics on all hardware and secondary network communications. The secondary control panel shall provide both local and remote annunciation of any detected component failures or repeated failure to establish communication to the system.

L. Controllers shall include all point inputs and outputs necessary to perform the specified control sequences. As a minimum, 50% of the point outputs shall be of the Universal type; that is, the outputs may be utilized either as modulating or two-state, allowing for additional system flexibility. In lieu of Universal outputs, provide a minimum of 50% spare outputs of each type via additional point termination boards or controllers. Analog outputs shall be industry standard signals such as 24 VAC floating control, allowing for interface to a variety of modulating actuators. Terminal equipment controllers utilizing proprietary control signals and actuators shall not be acceptable.

M. Provide each secondary control panel with sufficient memory to accommodate point databases, operating programs, local alarming and local trending. All databases and programs shall be stored in non-volatile EEPROM, EPROM and PROM. The controllers shall be able to return to full normal operation without user intervention after a power failure of unlimited duration. Provide uninterruptible power supplies (UPSs) of sufficient capacities for all terminal controllers that do not meet this protection requirement. Operating programs shall be field-selectable for specific applications. In addition, specific applications may be modified to meet the user's exact control strategy requirements, allowing for additional system flexibility. Controllers that require factory changes of all applications are not acceptable. Controller shall have a minimum of 16K EPROM or EEPROM.

N. The secondary control panels shall be powered from a 24 VAC source provided by this contractor and shall function normally under an operating range of 18 – 28 VAC (-25% – 17%), allowing for power source fluctuations and voltage drops. Install plenum data line and sensor cable in accordance with local code and NEC. The BMS contractor shall provide a dedicated power source and separate isolation transformer for each controller to function normally under the specified operating range. The controllers shall also function normally under ambient conditions of 32º – 122ºF (0º – 50ºC) and 10% – 95% RH (non-condensing). Provide each controller with a suitable cover or enclosure to protect the intelligence board assembly. Power supply must be rated at a minimum of 125% of power consumption and shall be of the fused or current limiting type. The BMS contractor shall provide 24 VAC power to the terminal units by utilizing:

1. The existing line voltage power trunk and installing separate isolation transformers for each controller.
2. Dedicated line voltage power source and isolation transformers at a central location and installing 24 VAC power trunk to supply multiple controllers in the area.

O. Environment. The controllers shall function normally under ambient conditions of 32º – 122ºF (0º – 50ºC) and 10% – 95% RH (non-condensing). Provide each controller with a suitable cover or enclosure to protect the circuit board assembly.

P. Immunity to noise. Operation shall be protected against electrical noise of 5 – 120Hz and from keyed radios up to 5W at 1m (3’).

2.10 SECONDARY CONTROL PANEL SOFTWARE

A. Provide all necessary software for a complete operating system as required. All software shall reside in each secondary control panel. Secondary control panels shall not be dependent upon any higher level computer or another controller for operation.

B. Secondary control panel software configured for CAV or VAV control algorithms shall include provisions for manual and automatic calibration of attached differential pressure transducer in order to maintain stable control and insuring against drift over time. Calibration shall be accomplished by stroking the terminal unit damper actuator to a 0% position so that a 0 CFM air volume reading is sensed. The controller shall automatically accomplish this whenever the system mode switches from occupied to unoccupied or vice versa. Manual calibration may be accomplished by either commanding the actuator to 0% via the POT or by depressing the room sensor override switch. Calibration of the transducer at the controller location shall not be necessary.

C. Each secondary controller shall perform its primary control function independent of primary controller LAN communication, or if LAN communication is interrupted. Reversion to a fail-safe mode of operation during LAN interruption is not acceptable. The controller shall receive its real-time data from the primary control panel time clock to insure LAN continuity. Each controller shall include algorithms incorporating proportional, integral and derivative (PID) control for all applications. All PI parameters shall be field-adjustable by the user via a portable operator’s terminal.

D. Secondary control panels shall support pressure independent terminal boxes including VAV cooling only, VAV with hot water or electric reheat, Fan-powered VAV and Fan-powered VAV with hot water or electric reheat. All VAV box control applications shall be field-selectable such that a single controller may be used in conjunction with any of the above types of terminal units to perform the specified sequences of control. This requirement must be met in order to allow for future design and application changes and to facilitate system expansions. Controllers that require factory application changes are not acceptable.

2.11 AIRFLOW TRACKING SYSTEM

A. This contractor is responsible for providing a complete flow tracking control system for each tracking pair. Quantity of tracking pairs shall be in accordance with contract documents.

B. The BMS shall include control of supply and return terminal units via DDC controllers for each tracking pair to maintain the required room pressure minimum ventilation (through constant volume control) and temperature control conditions. The use of individual VAV box controllers communicating through the BMS network to do flow tracking is acceptable. If the BMS network fails, the flow tracking controllers shall continue to operate in a stand alone mode for constant volume controller.

C. The terminal units shall be equipped with electrically actuated dampers controlled by the BMS. Lab Room Controllers shall meet all requirements as listed herein.

D. The pressurization of the space shall be accomplished by tracking supply and return airflows to maintain flow differential setpoint. Quantity of terminal units shall be as shown on drawings. Because of the need to operate with doors open and because the variable operation of the rest of the buildings ventilation systems continuously affects the building pressure level, controlling directly from room differential pressure as the primary control loop is not practical and is not acceptable. The actual volumes of air entering and leaving the space shall be measured, reported and recorded at the central monitoring station through the CAV/RAV box controllers air velocity sensors. When the controller is not able to maintain the programmed differential flow between the supply and return boxes, an alarm will be reported locally and at the central monitoring station. Preset alarm limits are not acceptable.

2.12 LABORATORY ROOM CONTROLLER

A. Provide Laboratory Room Controls for each CAV/VAV supply and return tracking pair as follows. Reference the sequences of operation for additional information.

1. The Laboratory Room Controller shall have the minimum control performance.

   a. Controlled Temperature Accuracy $\pm$1.0°F

   b. Flow Control Speed of Response 1 second

   c. Flow Measurement Range 0” to 2.0” w.c.

   d. Flow Measurement Accuracy $\pm$3.5% of reading

2. The Laboratory Room Controller shall have the following Agency Listings:

   a. FCC, Class B, subpart J UL 916 Energy Management.

2.13 DDC EQUIPMENT

A. Operator Workstation: Existing Operator Workstation shall be updated to include all points for this project as described in the sequences of operation.

B. Control Units: Modular, comprising processor board with programmable, nonvolatile, random-access memory;; integral interface equipment; and backup power source.

1. Units monitor or control each I/O point; process information; execute commands from other control units, devices, and operator stations; and download from or upload to operator workstation or diagnostic terminal unit.
2. Stand-alone mode control functions operate regardless of network status. Functions include the following:
   a. Global communications.
   b. Discrete/digital, analog, and pulse I/O.
   c. Monitoring, controlling, or addressing data points.
   d. Software applications, scheduling, and alarm processing.
   e. Testing and developing control algorithms without disrupting field hardware and controlled environment.
3. Standard Application Programs:
   a. Electric Control Programs: Demand limiting, duty cycling, automatic time scheduling, start/stop time optimization, night setback/setup, onoff control with differential sequencing, staggered start, antishort cycling, PID control, DDC with fine tuning, and trend logging.
   b. HVAC Control Programs: Optimal run time, supply-air reset, and enthalpy switchover.
   c. Chiller Control Programs: Control function of condenser-water reset, chilled-water reset, and equipment sequencing.
   d. Programming Application Features: Include trend point; alarm processing and messaging; weekly, monthly, and annual scheduling; energy calculations; run-time totalization; and security access.
   e. Remote communications.
   f. Maintenance management.
   g. Units of Measure: Inch-pound and SI (metric).
4. Local operator interface provides for download from or upload to operator workstation or diagnostic terminal unit.
5. ASHRAE 135 Compliance: Control units shall use ASHRAE 135 protocol and communicate using ISO 8802-3 (Ethernet) datalink/physical layer protocol.
6. LonWorks Compliance: Control units shall use LonTalk protocol and communicate using EIA/CEA 709.1 datalink/physical layer protocol.

C. Local Control Units: Modular, comprising processor board with electronically programmable, nonvolatile, read-only memory; and backup power source.

1. Units monitor or control each I/O point, process information, and download from or upload to operator workstation or diagnostic terminal unit.
2. Stand-alone mode control functions operate regardless of network status. Functions include the following:
   a. Global communications.

b. Discrete/digital, analog, and pulse I/O.

c. Monitoring, controlling, or addressing data points.

3. Local operator interface provides for download from or upload to operator workstation or diagnostic terminal unit.

4. ASHRAE 135 Compliance: Control units shall use ASHRAE 135 protocol and communicate using ISO 8802-3 (Ethernet) datalink/physical layer protocol.

5. LonWorks Compliance: Control units shall use LonTalk protocol and communicate using EIA/CEA 709.1 datalink/physical layer protocol.

D. I/O Interface: Hardwired inputs and outputs may tie into system through controllers. Protect points so that shorting will cause no damage to controllers.

1. Binary Inputs: Allow monitoring of on-off signals without external power.
2. Pulse Accumulation Inputs: Accept up to 10 pulses per second.
3. Analog Inputs: Allow monitoring of low-voltage (0- to 10-V dc), current (4 to 20 mA), or resistance signals.
4. Binary Outputs: Provide on-off or pulsed low-voltage signal, selectable for normally open or normally closed operation with three-position (on-off-auto) override switches and status lights.
5. Analog Outputs: Provide modulating signal, either low voltage (0- to 10-V dc) or current (4 to 20 mA) with status lights, two-position (auto-manual) switch, and manually adjustable potentiometer.
6. Tri-State Outputs: Provide two coordinated binary outputs for control of three-point, floating-type electronic actuators.
7. Universal I/Os: Provide software selectable binary or analog outputs.

E. Power Supplies: Transformers with Class 2 current-limiting type or overcurrent protection; limit connected loads to 80 percent of rated capacity. DC power supply shall match output current and voltage requirements and be full-wave rectifier type with the following:

1. Output ripple of 5.0 mV maximum peak to peak.
2. Combined 1 percent line and load regulation with 100-mic.sec. response time for 50 percent load changes.
3. Built-in overvoltage and overcurrent protection and be able to withstand 150 percent overload for at least 3 seconds without failure.

F. Power Line Filtering: Internal or external transient voltage and surge suppression for workstations or controllers with the following:

1. Minimum dielectric strength of 1000 V.
2. Maximum response time of 10 nanoseconds.
3. Minimum transverse-mode noise attenuation of 65 dB.
4. Minimum common-mode noise attenuation of 150 dB at 40 to 100 Hz.

2.14 UNITARY CONTROLLERS

A. Unitized, capable of stand-alone operation with sufficient memory to support its operating system, database, and programming requirements, and with sufficient I/O capacity for the application.

1. Configuration: diagnostic LEDs for power, communication, and processor; wiring termination to terminal strip or card connected with ribbon cable; memory with bios; and 72 hour battery backup.
2. Operating System: Manage I/O communication to allow distributed controllers to share real and virtual object information and allow central monitoring and alarms. Perform automatic system diagnostics; monitor system and report failures.
3. ASHRAE 135 Compliance: Communicate using read (execute and initiate) and write (execute and initiate) property services defined in ASHRAE 135. Reside on network using MS/TP datalink/physical layer protocol and have service communication port for connection to diagnostic terminal unit.
4. LonWorks Compliance: Communicate using EIA/CEA 709.1 datalink/physical layer protocol using LonTalk protocol.
5. Enclosure: Dustproof rated for operation at 32 to 120 deg F.
6. Enclosure: Waterproof rated for operation at 40 to 150 deg F.

2.15 ALARM PANELS

A. All alarming shall be displayed at the existing BMS workstation.

2.16 ANALOG CONTROLLERS

A. Step Controllers: 6- or 10-stage type, with heavy-duty switching rated to handle loads and operated by electric motor.

B. Electric, Outdoor-Reset Controllers: Remote-bulb or bimetal rod-and-tube type, proportioning action with adjustable throttling range, adjustable set point, scale range minus 10 to plus 70 deg F, and single- or double-pole contacts.

C. Electronic Controllers: Wheatstone-bridge-amplifier type, in steel enclosure with provision for remote-resistance readjustment. Identify adjustments on controllers, including proportional band and authority.

1. Single controllers can be integral with control motor if provided with accessible control readjustment potentiometer.

D. Fan-Speed Controllers: Solid-state model providing field-adjustable proportional control of motor speed from maximum to minimum of 55 percent and on-off action below minimum fan speed. Controller shall briefly apply full voltage, when motor is started, to rapidly bring motor up to minimum speed. Equip with filtered circuit to eliminate radio interference.

E. Receiver Controllers: Single- or multiple-input models with control-point adjustment, direct or reverse acting with mechanical set-point adjustment with locking device, proportional band adjustment, authority adjustment, and proportional control mode.

1. Remote-control-point adjustment shall be plus or minus 20 percent of sensor span, input signal of 3 to 13 psig.

2. Proportional band shall extend from 2 to 20 percent for 5 psig.
3. Authority shall be 20 to 200 percent.
4. Air-supply pressure of 18 psig, input signal of 3 to 15 psig, and output signal of zero to supply pressure.
5. Gages: 1-1/2 inches in diameter, 2.5 percent wide-scale accuracy, and range to match transmitter input or output pressure.

2.17 TIME CLOCKS

A. Manufacturers:

1. ATC-Diversified Electronics.
2. Grasslin Controls Corporation.
3. Paragon Electric Co., Inc.
4. Precision Multiple Controls, Inc.
5. SSAC Inc.; ABB USA.
6. TCS/Basys Controls.
7. Theben AG - Lumilite Control Technology, Inc.
8. Time Mark Corporation.

B. Seven-day, programming-switch timer with synchronous-timing motor and sevenday dial; continuously charged, nickel-cadmium-battery-driven, eight-hour, powerfailure carryover; multiple-switch trippers; minimum of two and maximum of eight signals per day with two normally open and two normally closed output contacts.

C. Solid-state, programmable time control with 4 separate programs each with up to 100 on-off operations; 1-second resolution; lithium battery backup; keyboard interface and manual override; individual on-off-auto switches for each program; 365-day calendar with 20 programmable holidays; choice of fail-safe operation for each program; system fault alarm; and communications package allowing networking of time controls and programming from PC.

2.18 ELECTRONIC SENSORS

A. Description: Vibration and corrosion resistant; for wall, immersion, or duct mounting as required.

B. Instruments and control devices shall be provided for all required points detailed herein. Instruments shall have accuracies as stated herein. Instrument characteristics such as hysteresis, relaxation time, span, and maximum and minimum limits, shall be accounted for in applications of instruments and controls. Not all devices specified may be required for this project.

C. Field wiring for each digital device shall be as per the manufacturer’s standard. The details of the wiring shall be included in the submittal.

D. Sensors for duct locations shall not be affected by vibrations encountered in normal duct systems.

E. Thermistor Temperature Sensors and Transmitters:

1. Manufacturers:
   a. BEC Controls Corporation.
   b. Ebtron, Inc.
   c. Heat-Timer Corporation.
   d. I.T.M. Instruments Inc.
   e. MAMAC Systems, Inc.
   f. RDF Corporation
   g. ACI
   h. Veris
   i. Schneider Electric
   j. Kele
2. Space temperature sensors shall match RUMC campus standards
3. Accuracy: Plus or minus .2%.
4. Wire: Twisted, shielded-pair cable.
5. Insertion Elements in Ducts: Single point, 18 inches long; use where not affected by temperature stratification or where ducts are smaller than 9 sq. ft.. Provide duct mounted metal housing with conduit entrance.
6. Insertion Elements in Ducts: Single point; use where not affected by temperature stratification or where ducts are smaller than 9sq ft. (1sq m). The length of the sensor shall be a minimum of one-third of the width of the duct with a maximum length of eighteen (18) inches. Provide duct mounted metal housing with conduit entrance.
7. Averaging Elements in Ducts: Use where prone to temperature stratification or where ducts are larger than 9sq ft (1sq m); length as required. The length of the sensor shall be twelve (12) feet minimum or one (1) linear foot per every one (1) sq ft of cut cross section, whichever is greater. Provide duct mounted metal housing with conduit entrance.
8. Insertion Elements for Liquids: Provide 304 stainless steel thermowell with tapered pattern, ¾ inch NPT external connection, ½ inch internal thread. Include lagging extension equal to insulation thickness where installed in insulated piping. Insertion length shall be a minimum of 1/3 of pipe diameter but in no case shall be less than 2 ½ inches and a maximum of ¾ pipe diameter or 6 inches, whichever is smaller.
9. Provide one (1) averaging temperature sensor for each preheat or heating coil in an air handling unit. The sensor shall be installed on the discharge side of the preheat coil.
10. Room Sensor Cover Construction: Manufacturer's standard locking covers.
    a. Set-Point Adjustment: LCD Display
    b. Set-Point Indication: LCD Display .

c. Thermometer: LCD Display

d. Color: white

e. Orientation: Vertical.

11. Outside-Air Sensors: Watertight inlet fitting, shielded from direct sunlight.

12. Room Security Sensors: Stainless-steel cover plate with insulated back and security screws.

F. RTDs and Transmitters:

1. Manufacturers:

a. BEC Controls Corporation.

b. MAMAC Systems, Inc.

c. RDF Corporation.

2. Accuracy: Plus or minus 0.2 percent at calibration point.

3. Wire: Twisted, shielded-pair cable.

4. Insertion Elements in Ducts: Single point**, 8 inches long; use where not affected by temperature stratification or where ducts are smaller than 9** sq. ft..

5. Averaging Elements in Ducts: 18 inches long use where prone to temperature stratification or where ducts are larger than 9 sq. ft.; length as required.

6. Insertion Elements for Liquids: Brass socket with minimum insertion length of 2-1/2 inches.

7. Room Sensor Cover Construction: Manufacturer's standard locking covers.

a. Set-Point Adjustment: [**Concealed**] [**Exposed**].

b. Set-Point Indication: [**Concealed**] [**Keyed**] [**Exposed**].

c. Thermometer: [**Concealed**] [**Exposed**] [**Red-reading glass**].

d. Color: White

e. Orientation: Vertical.

8. Outside-Air Sensors: Watertight inlet fitting, shielded from direct sunlight.

9. Room Security Sensors: Stainless-steel cover plate with insulated back and security screws.

G. Humidity Sensors: Bulk polymer sensor element.

1. Manufacturers:

a. BEC Controls Corporation.

b. General Eastern Instruments.

c. MAMAC Systems, Inc.

d. ROTRONIC Instrument Corp.

e. TCS/Basys Controls.

f. Vaisala.

g. ACI
h. Veris
i. Schneider Electric
j. Kele

2. Accuracy: [**2**] percent full range with linear output.
3. Room Sensor Range: 0 to 95 percent relative humidity.
4. Room Sensor Cover Construction: Manufacturer's standard locking covers.
   a. Set-Point Adjustment: LCD Display
   b. Set-Point Indication: LCD Display
   c. Thermometer: LCD Display
   d. Color: White
   e. Orientation: Vertical.
5. Duct Sensor: 0 to 100 percent relative humidity range with element guard and mounting plate.
6. Outside-Air Sensor: 0 to 100 percent relative humidity range with mounting enclosure, suitable for operation at outdoor temperatures of minus 40 to plus 170 deg F.
7. Duct and Sensors: With element guard and mounting plate, range of 0 to 100 percent relative humidity.
8. Sensors shall RUMC campus standards or pre-approved equal. H. Pressure

Transmitters/Transducers:

1. Manufacturers:
   a. BEC Controls Corporation.
   b. General Eastern Instruments.
   c. MAMAC Systems, Inc.
   d. ROTRONIC Instrument Corp.
   e. TCS/Basys Controls.
   f. Vaisala.
   g. Veris
   h. Setra
2. Static-Pressure Transmitter: Nondirectional sensor with suitable range for expected input, and temperature compensated.
   a. Accuracy: 1 percent of full scale with repeatability of 0.1 percent.
   b. Output: 4 to 20 mA.
   c. Building Static-Pressure Range: 0- to 0.25-inch wg.
   d. Duct Static-Pressure Range: 0- to 5-inch wg.

e. Provide a Setra M264 or pre-approved equal.

f. These sensors shall be used for control of fan VFDs, monitoring of filter DP, etc.

3. Water Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig operating pressure; linear output 4 to 20 mA.
4. Water Differential-Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig operating pressure and tested to 300-psig; linear output 4 to 20 mA.
5. Differential-Pressure Switch (Air or Water): Snap acting, with pilot-duty rating and with suitable scale range and differential.
6. Pressure Transmitters: Direct acting for gas, liquid, or steam service; range suitable for system; linear output 4 to 20 mA.
7. Instruments and control devices shall be provided for all required points detailed herein. Instruments shall have accuracies as stated herein. Instrument characteristics such as hysteresis, relaxation time, span, and maximum and minimum limits, shall be accounted for in applications of instruments and controls. Not all devices specified may be required for this project.
8. Field wiring for each digital device shall be as per the manufacturer's standard. The details of the wiring shall be included in the submittal.
9. Sensors for duct locations shall not be affected by vibrations encountered in normal duct systems.
10. Temperature Sensors

I. Pressure Transmitters: Direct acting for gas, liquid or steam service; range suitable for system; proportional output 4-20 mA.

1. 2-wire variable capacitance.
2. NEMA 4X enclosure.
3. Rated for 0% to 100% RH and -40ºF – 185ºF.
4. Dual component housing with a moisture barrier completely isolating the electronic circuitry from the field wiring and calibration terminals.
5. Operates with a 10 – 55 VDC power supply.
6. Zero and span adjustments.
7. Accuracy shall be $\pm$ 0.075% of calibrated span.
8. Transmitter shall be furnished complete with factory mounted 5-valve manifold manufactured by Anderson Greenwood & Co. Model M6T or pre-approved equal.
9. Provide Rosemount 2051DP, Veris, Setra or pre-approved equal.

J. Damper End Switches

1. Provide a heavy-duty switch with plug-in, oil tight, watertight and NEMA 3 construction (unless exposed to outside air type conditions) sensing of damper position. Shall be rated to operate from -40°F – 212°F (-40°C – 100°C). Shall have a side rotary switch for use with

interchangeable levers. Shall have LED position and operation indicators. Shall be Omron D4A series or pre-approved equal.

K. Air Differential Pressure Switches

1. Diaphragm type air differential pressure switches with die-cast aluminum housing, adjustable setpoint and minimum 5A switch rating at 120 VAC, SPDT switches and the switch pressure range shall be suited for the application. Provide Dwyer. Switch shall be manual reset type. High and low ports shall be 1/8 inch NPT connected to angle type tips designed to sense pressure.

L. Point Leak Detector

1. Leak detector shall have mounting feet with legs adjustable up to 1-1/2", gold-plated water detection probes, adjustable height, a green LED to indicate power, a red LED to indicate water detected, SPDT alarm contacts. The enclosure shall be cast aluminum, weatherproof with adjustable legs. The leak detector shall operate between 11 and 27 VAC/DC.

M. Equipment operation sensors as follows:

1. Status Inputs for Fans: Differential pressure switch with adjustable range of 0" - 5" wg (0 - 1243 Pa).

N. Current Sensing Relay

1. Provide and install current sensors for all motor status points. Current sensor shall combine a status sensor for monitoring positive status and a command relay for starting or stopping motors in a single package. Current sensor shall be split core, 2-wire, loop powered and sized for expected amperage. Unit shall be UL listed. Provide status LEDs for current sensed below setpoint, current sensed above setpoint and loop power failure. The current sensor output shall be N.O., solid state and rated for 0.1A at 30 VAC/DC. The relay output shall be N.O. and rated for 5A resistive, 3A inductive at 30 VDC, 240 VAC. Current sensor with command relay shall be a Hawkeye model H938 or pre-approved equal. O. Magnetic Latching Relay

1. Magnetic latching relays shall require one pulse of coil power to move their contacts in one direction and a second pulse to move them back. A permanent magnet maintains the last position until the second pulse moves the contacts back to the original state. Interruption of power shall not be capable of transitioning the contacts. Provide Magnecraft Series 755 or pre-approved equal.

P. Mechanical Latching Relay

1. Mechanical latching relays shall use a locking mechanism to hold their contacts in the last set position until commanded to change state by means of energizing a second coil. Interruption of power shall not be capable of transitioning the contacts. Provide Magnecraft Series 385 or pre-approved equal.

Q. Electric Low-Limit Duct Thermostat: Snap-acting, single-pole, single-throw, automatic-reset switch that trips if temperature sensed across any 12" of bulb length is equal to or below set point. Setpoint shall be adjustable.

1. Bulb Length: Minimum 20'.
2. Quantity: one (1) thermostat for each cooling coil or for every 20 sq ft of coil surface, whichever is greater.
3. Each freezestat shall be an input to the BMS and shall be separately alarmed.

R. Room Sensor Cover Construction: Manufacturer's standard locking covers.

1. Set-Point Adjustment: LCD Display
2. Set-Point Indication: LCD Display
3. Thermometer: LCD Display
4. Color: White
5. Orientation: Vertical.

S. Room sensor accessories include the following:

1. Insulating Bases: For sensors located on exterior walls.
2. Adjusting Key: As required for calibration and cover screws.

2.19 STATUS SENSORS

A. Status Inputs for Fans: Differential-pressure switch with pilot-duty rating and with adjustable range of 0- to 5-inch wg.

B. Status Inputs for Pumps: Differential-pressure switch with pilot-duty rating and with adjustable pressure-differential range of 8 to 60 psig, piped across pump.

C. Status Inputs for Electric Motors: Comply with ISA 50.00.01, current-sensing fixed- or split-core transformers with self-powered transmitter, adjustable and suitable for 175 percent of rated motor current.

D. Voltage Transmitter (100- to 600-V ac): Comply with ISA 50.00.01, single-loop, self-powered transmitter, adjustable, with suitable range and 1 percent full-scale accuracy.

E. Power Monitor: 3-phase type with disconnect/shorting switch assembly, listed voltage and current transformers, with pulse kilowatt hour output and 4- to 20-mA kW output, with maximum 2 percent error at 1.0 power factor and 2.5 percent error at 0.5 power factor.

F. Current Switches: Self-powered, solid-state with adjustable trip current, selected to match current and system output requirements.

G. Electronic Valve/Damper Position Indicator: Visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.

H. Water-Flow Switches: Bellows-actuated mercury or snap-acting type with pilotduty rating, stainless-steel or bronze paddle, with appropriate range and differential adjustment, in NEMA 250, Type 1 enclosure.

1. Manufacturers:
    a. BEC Controls Corporation.
    b. I.T.M. Instruments Inc.

2.20 GAS DETECTION EQUIPMENT

A. Manufacturers:

1. B. W. Technologies.

2. CEA Instruments, Inc.
3. Ebtron, Inc.
4. Gems Sensors Inc.
5. Greystone Energy Systems Inc.
6. Honeywell International Inc.; Home & Building Control.
7. INTEC Controls, Inc.
8. I.T.M. Instruments Inc.
9. MSA Canada Inc.
10. QEL/Quatrosense Environmental Limited.
11. Sauter Controls Corporation.
12. Sensidyne, Inc.
13. TSI Incorporated.
14. Vaisala.
15. Vulcain Inc.

B. Carbon Monoxide Detectors: Single or multichannel, dual-level detectors using solid-state plug-in sensors with a 3-year minimum life; suitable over a temperature range of 32 to 104 deg F; with 2 factory-calibrated alarm levels at 50 and 100 ppm.

C. Carbon Dioxide Sensor and Transmitter: Single detectors using solid-state infrared sensors; suitable over a temperature range of 23 to 130 deg F and calibrated for 0 to 2 percent, with continuous or averaged reading, 4- to 20-mA output;, for wall mounting.

D. Oxygen Sensor and Transmitter: Single detectors using solid-state zircon cell sensing; suitable over a temperature range of minus 32 to plus 1100 deg F and calibrated for 0 to 5 percent, with continuous or averaged reading, 4- to 20-mA output; for wall mounting.

E. Occupancy Sensor: Passive infrared, with time delay, daylight sensor lockout, sensitivity control, and 180-degree field of view with vertical sensing adjustment; for flush mounting.

2.21 ROOM PRESSURE MONITOR

A. The alarm monitor device shall have an LCD display, room pressure transmitters, and door switches which continuously display pressure direction, temperature and humidity.

B. The BMS shall monitor the room pressure monitor through a BACnet interface.

C. Acceptable Mfr: Setra Flex

2.22 FLOW MEASURING STATIONS/DEVICES

A. Airflow Measuring Station

1. Station
    a. Airflow measuring stations required to accomplish the specified control sequence shall be furnished under this section but installed under the sheet metal section.
    b. Each airflow measuring station shall measure airflow by means of a network of static and total pressure sensors factory positioned and connected in parallel to produce an averaged velocity pressure. The measured velocity pressure converted to airflow (CFM) shall have an accuracy of 2% of the full scale throughout the velocity range from 700 to 4,000FPM when measured under ideal laboratory conditions. The location of stations shall meet manufacturer's guidelines.
    c. The maximum resistance to airflow shall not exceed 0.6 times the velocity head. The unit shall be suitable to withstand temperatures up to 250ºF.
    d. All interconnecting tubing between the air measuring and any remote metering or control shall be furnished and installed by the supplier of the station. A minimum of one (1) static and one (1) total pressure sensor shall be used for every 16 sq in of duct cross sectional area for ducts up to

       4 sq ft in cross section. For larger ducts, a minimum of one (1) static and one (1) total pressure sensor shall be used for every 36sq in of duct cross sectional area.
    e. Interconnecting sensor manifolds shall equalize and relate each type of sensor measurement into one (1) total pressure and one (1) static pressure metering port. The permanent system pressure loss created by the unit shall not exceed .15 of the velocity head. Each airflow measuring station shall consist of 16-gauge sheet metal casing and an air straightening section with an open face area not less than 97%. The sheet metal contractor shall install air measuring stations.
    f. Provide Air Monitor Fan-E or equal with an accuracy of ±2%, a turndown of 6 to 1 and no pressure loss across the station.
    g. Final locations to be coordinated with sheet-metal contractor and manufacturer to ensure installed actual accuracy meets specifications.
2. Velocity Pressure Sensor for Airflow Measuring Stations
    a. Range: 0.1 – 0.5" wg (Size based on AFMS Output).
    b. Accuracy: ± 0.25”wg
    c. Transmitter: 4 – 20 mA.
    d. Pressure sensor shall be type provided by the airflow measuring station manufacturer and shall be purchased from the airflow measuring station manufacturer.
    e. Acceptable Mfr: Ebtron or Ruskin B. Fan Inlet Airflow Traverse Probe
1. Provide airflow traverse probes mounted in the fan inlet capable of continuously measuring the air volume of the respective fan.

2. The fan inlet airflow traverse probes shall contain multiple total and static pressure sensors placed at concentric area centers along the exterior surface of the cylindrical probes and internally connected to their respective averaging manifolds. Sensor shall not protrude beyond the surface of the probe, nor be adversely affected by particle contamination normally present in building system airflows.
3. The fan inlet airflow traverse probes shall have symmetrical averaging signal takeoffs and shall be of aluminum construction with hard anodized finish with galvanized steel mounting hardware.
4. The fan inlet airflow traverse probes shall not significantly impact fan performance or contribute to fan generated noise levels. The probes shall be capable of producing steady, non-pulsating signals of standard total and static pressure, without need for flow corrections or factors, with an accuracy of 3% of actual flow over a fan operating rang of 6 to 1 capacity turndown.
5. Provide multiple fan inlet airflow traverse probes if there are multiple fans or if required by a single fan.
6. The fan inlet traverse probes shall be the VOLU-probe/FI as manufactured by Air Monitor or pre-approved equal.
7. Velocity Pressure Sensor for Fan Inlet Measuring Stations
    a. Range: 0.1 – 0.5" wg (Size based on AFMS Output).
    b. Accuracy: ± 0.25”wg
    c. Transmitter: 4 – 20 mA.
    d. Pressure sensor shall be type provided by the fan inlet probe manufacturer and shall be purchased from the fan inlet probe manufacturer.
8. The monitor/controller shall be capable of direct measurement of airflow through an outside air inlet and produce dual outputs; one (1) representing the measured airflow and the other to control the inlet damper.
9. The monitor/controller shall contain an integral multi-line liquid crystal display for use during the configuration and calibration processes and to display two (2) measured processes (volume, velocity, temperature) during normal operation. All configuration, output scaling, calibration and controller tuning will be performed digitally in the on-board microprocessor via input pushbuttons.
10. The monitor/controller shall measure inlet airflow with an accuracy of ±5% of reading over a range of 150-600 FPM or 250-1000 FPM and not have its reading affected by the presence of directional or gusting wind. Measured airflow shall be density corrected for ambient temperature variances and atmospheric pressure due to site altitude.
11. The monitor/controller shall interface with existing building management systems, accepting inputs for fan system start, economizer mode operation and an external controller setpoint and provide flow deviation alarm outputs.
12. The sensors shall be constructed of materials that resist corrosion due to the presence of salt or chemicals in the air; all non-painted surfaces shall be constructed of stainless steel. The electronics enclosure shall be NEMA 1 [NEMA 4; NEMA 4 with enclosure heater and insulation].

13. The monitor/controller shall be the VOLU-flo/OAM as manufactured by Air Monitor or pre-approved equal.

C. Single Channel Energy/Flowmeter

1. The Energy/Flowmeter shall be a Single Channel, Clamp-on- Transit Time Ultrasonic Energy Meter.
2. The furnished Energy/Flowmeter shall be of a clamp-on design precluding the requirement of penetrating into the pipe. Also, the Energy/Flow meter shall be digital microprocessor based utilizing using the Transit-Time flow measuring technique. Wetted transducer or electrodes, or flow measuring techniques previously described will not be acceptable.
3. The Energy/Flowmeter shall provide automatic transducer spacing, automatic Reynold's number and liquid sonic velocity variation compensation and live zero flow measurement. The Energy/Flowmeter shall have the ability to indicate flow rate, flow velocity, total flow, energy rate, energy Total, Temperature in and out, signal strength, liquid sonic velocity and Reynold's Number. The Energy/Flowmeter shall provide self and application diagnostics to isolate any fault conditions due to either equipment failure or abnormal process conditions.
4. The Energy/Flowmeter electronics shall be powered by 115 VAC, 60 HZ. Two (2) isolated 4 – 20 mA outputs proportional to flow or Energy shall be provided. In addition, an RS-232 Digital output and separate test port for diagnostic and calibration functions. An optional digital interface shall be available providing Modbus and Ethernet communications. The system shall be capable of interface to all common BMS systems.
5. Temperature measurement shall be via RTD's. The temperature sensors may be insert or surface mount. Where surface mount sensors are used they must be insulated with a minimum of 2" of insulation for accurate performance sensors utilizing temperature transmitters or sensors other than RTD's shall not be permitted
6. The Energy/Flowmeter shall have an intrinsic accuracy of $\pm$1% to 2% of flow over a range of $\pm$40 fps. Repeatability shall be 0.1% of flow sensitivity of 0.001 fps at any flow rate including a zero flow condition.
7. The Energy/Flowmeter shall also possess the following capabilities:
    a. Simultaneous measurement of 1 Energy and 1 Flow Measurement.
    b. Security password protection for sites.
    c. Reverse flow and empty pipe detection.
8. The System components shall be:
    a. One (1) Single Channel Energy/Flow Computer.
    b. One (1) Pair of Transducers.
    c. One (1) Mounting Frames and related hardware.
    d. One (1) Spacer Bar.
    e. One (1) Transducer Cable.
    f. One (1) Thermal RTD's (Set).
    g. Two (2) Temperature Cable.

h. One (1) Energy Manual.

9. The energy/flowmeter shall be manufactured by Flexim, Siemens, General Electric or pre-approved equal.

2.23 FLOW MEASURING STATIONS

A. Duct Airflow Station: Combination of air straightener and multiport, self-averaging pitot tube station.

1. Manufacturers:
   a. Air Monitor Corporation.
   b. Wetmaster Co., Ltd.
   c. Ebtron
   d. Ruskin
2. Casing: Galvanized-steel frame.
3. Flow Straightener: Aluminum honeycomb, 3/4-inch parallel cell, 3 inches deep.
4. Sensing Manifold: Copper manifold with bullet-nosed static pressure sensors positioned on equal area basis.

2.24 THERMOSTATS

A. Manufacturers:

1. Erie Controls.
2. Danfoss Inc.; Air-Conditioning and Refrigeration Div.
3. Heat-Timer Corporation.
4. Sauter Controls Corporation.
5. tekmar Control Systems, Inc.
6. Theben AG - Lumilite Control Technology, Inc.

B. Combination Thermostat and Fan Switches: Line-voltage thermostat with pushbutton or lever-operated fan switch.

1. Label switches [**"FAN ON-OFF"**] [**"FAN HIGH-LOW-OFF"**] [**"FAN HIGH-MED-LOWOFF"**].
2. Mount on single electric switch box.

C. Electric, solid-state, microcomputer-based room thermostat with remote sensor.

1. Automatic switching from heating to cooling.
2. Preferential rate control to minimize overshoot and deviation from set point.
3. Set up for four separate temperatures per day.
4. Instant override of set point for continuous or timed period from 1 hour to 31 days.
5. Short-cycle protection.

6. Programming based on [**weekday, Saturday, and Sunday**] [**every day of week**].
7. Selection features include degree F or degree C display, 12- or 24-hour clock, keyboard disable, remote sensor, and fan on-auto.
8. Battery replacement without program loss.
9. Thermostat display features include the following:
    a. Time of day.
    b. Actual room temperature.
    c. Programmed temperature.
    d. Programmed time.
    e. Duration of timed override.
    f. Day of week.
    g. System mode indications include "heating," "off," "fan auto," and "fan on."

D. Low-Voltage, On-Off Thermostats: NEMA DC 3, 24-V, bimetal-operated, mercuryswitch type, with adjustable or fixed anticipation heater, concealed set-point adjustment, 55 to 85 deg F set-point range, and 2 deg F maximum differential.

E. Line-Voltage, On-Off Thermostats: Bimetal-actuated, open contact or bellowsactuated, enclosed, snap-switch or equivalent solid-state type, with heat anticipator; listed for electrical rating; with concealed set-point adjustment, 55 to 85 deg F set-point range, and 2 deg F maximum differential.

1. Electric Heating Thermostats: Equip with off position on dial wired to break ungrounded conductors.
2. Selector Switch: Integral, manual on-off-auto.

F. Remote-Bulb Thermostats: On-off or modulating type, liquid filled to compensate for changes in ambient temperature; with copper capillary and bulb, unless otherwise indicated.

1. Bulbs in water lines with separate wells of same material as bulb.
2. Bulbs in air ducts with flanges and shields.
3. Averaging Elements: Copper tubing with either single- or multiple-unit elements, extended to cover full width of duct or unit; adequately supported.
4. Scale settings and differential settings are clearly visible and adjustable from front of instrument.
5. On-Off Thermostat: With precision snap switches and with electrical ratings required by application.
6. Modulating Thermostats: Construct so complete potentiometer coil and wiper assembly is removable for inspection or replacement without disturbing calibration of instrument.

G. Fire-Protection Thermostats: Listed and labeled by an NRTL acceptable to authorities having jurisdiction; with fixed or adjustable settings to operate at not less than 75 deg F above normal maximum operating temperature, and the following:

1. Reset: Manual.

2. Reset: Automatic, with control circuit arranged to require manual reset at central control panel; with pilot light and reset switch on panel labeled to indicate operation.

H. Pneumatic Room Thermostats: One pipe, fully proportional with adjustable throttling range and tamperproof locking settings, direct or reverse acting as required. Factory calibrated at 2.5 psig/deg F.

1. Factory Calibration: 2.5 psig/deg F.
2. Range: 45 to 85 deg F.
3. Sensitivity Adjustment Range: 1 to 4 psig/deg F.
4. Dual-Temperature Thermostats: Automatic changeover from normal setting to lower setting for unoccupied cycles, with manual-reset lever to permit return to normal temperatures during unoccupied cycles, with automatic reset to normal during next cycle of operation.
5. Limits: Field adjustable, to limit setting cooling set point below 75 deg F, and heating set point above 75 deg F.
6. Room Thermostat Cover Construction: Manufacturer's standard locking covers.
    a. Set-Point Adjustment: [**Concealed**] [**Exposed**].
    b. Set-Point Indication: [**Concealed**] [**Keyed**] [**Exposed**].
    c. Thermometer: [**Concealed**] [**Exposed**].
    d. Color: white
    e. Orientation: Vertical.
7. Room thermostat accessories include the following:
    a. Insulating Bases: For thermostats located on exterior walls.
    b. Thermostat Guards: [Locking; heavy-duty, transparent plastic; mounted on separate base] [Metal wire, tamperproof].
    c. Adjusting Key: As required for calibration and cover screws.
    d. Aspirating Boxes: For flush-mounted aspirating thermostats.
    e. Set-Point Adjustment: 1/2-inch- diameter, adjustment knob.

I. Immersion Thermostat: Remote-bulb or bimetal rod-and-tube type, proportioning action with adjustable throttling range and adjustable set point.

J. Airstream Thermostats: Two-pipe, fully proportional, single-temperature type; with adjustable set point in middle of range, adjustable throttling range, plug-in test fitting or permanent pressure gage, remote bulb, bimetal rod and tube, or averaging element.

K. Electric, Low-Limit Duct Thermostat: Snap-acting, single-pole, single-throw, manual- or automatic- reset switch that trips if temperature sensed across any 12 inches of bulb length is equal to or below set point.

1. Bulb Length: Minimum 20 feet.
2. Quantity: One thermostat for every 20 sq. ft. of coil surface.

L. Electric, High-Limit Duct Thermostat: Snap-acting, single-pole, single-throw, manual- or automatic- reset switch that trips if temperature sensed across any 12 inches of bulb length is equal to or above set point.

1. Bulb Length: Minimum 20 feet.
2. Quantity: One thermostat for every 20 sq. ft. of coil surface.

M. Heating/Cooling Valve-Top Thermostats: Proportional acting for proportional flow, with molded-rubber diaphragm, remote-bulb liquid-filled element, direct and reverse acting at minimum shutoff pressure of 25 psig, and cast housing with position indicator and adjusting knob.

2.25 HUMIDISTATS

A. Manufacturers:

1. MAMAC Systems, Inc.
2. ROTRONIC Instrument Corp.

B. Pneumatic Room Humidistats: Wall-mounting, proportioning type with adjustable throttling range, 0 to 100 percent operating range, and cover matching room thermostat cover.

C. Duct-Mounting Humidistats: Electric insertion, 2-position type with adjustable, 2 percent throttling range, 20 to 80 percent operating range, and single- or doublepole contacts.

D. Pneumatic Duct-Mounting Humidistats: Proportioning type with adjustable throttling range, 0 to 100 percent operating range, in galvanized-steel duct box.

2.26 ACTUATORS

A. Electric Valve Actuation

1. Actuator shall have electronic, proportional control and shall be direct-coupled with spring return.
2. Actuators shall be equipped with a permanent manual override hand wheel and visual and electronic stroke indicators.
3. Operating Voltage: 24 or 120 VAC.
4. Input Signal: 0-10 VDC, 4-20 mA.
5. Power Consumption: 18VA maximum (valves 2” and under), 28VA maximum (valves 21/2”-4”).
6. Spring return time: 15 seconds maximum.
7. Nominal Force: 225lb minimum (valves 2” and under), 610lb (valves 2-1/2”-4”).
8. Stroke: ¾”maximum (valves 2” and under), 1-1/2” (valves 2-1/2”-4”).
9. For use when the maximum media temperature is 300F.
10. Acceptable Mfr: Belimo, Schneider Electric, Bray

2.27 DAMPER ACTUATION

A. All damper actuation shall be electric. Pneumatic actuation is not acceptable.

B. Size actuators for running torque calculated as follows:

1. Parallel-Blade Damper with Edge Seals:7”-lb/sq. ft. (86.8 kg-cm/sq. m) of damper.
2. Opposed-Blade Damper with Edge Seals: 5”-lb/sq. ft. (62 kg-cm/sq. m) of damper.
3. Parallel-Blade Damper without Edge Seals: 4”-lb/sq. ft (49.6 kg-cm/sq. m) of damper.
4. Opposed-Blade Damper without Edge Seals: 3”-lb/sq. ft. (37.2 kg-cm/sq. m) of damper.
5. Dampers with 2” to 3” wg (500 to 750 Pa) of Pressure Drop or Face Velocities of 1000 to 2500 fpm (5 to 13 m/s): Increase running torque by 1.5.
6. Dampers with 3” to 4” wg (750 to 1000 Pa) of Pressure Drop or Face Velocities of 2500 to 3000 fpm (13 to 15 m/s): Increase running torque by 2.0.

C. All damper actuators shall meet the following requirements:

1. Damper actuators shall have external adjustable stops to limit the stroke in either direction.
2. All damper actuators shall have sufficient power to overcome friction of damper linkage and air pressure acting on louvers and to operate the damper smoothly throughout the entire damper range.
3. Actuators shall be sized with a torque greater than 150% of the design damper torque.
4. Actuators shall have mounting arrangement for location outside of the air stream. The damper actuators shall be mounted on the damper extension so that it is not burned in the wall construction.
5. Damper actuators shall fail-safe in either the normally open or normally closed position in the event of power failure, signal failure or compressed air failure. Fail Safe Positions are as follows:
    a. Outside Air Dampers — Normally Closed
    b. Return Air Dampers — Normally Open
    c. Exhaust Air Dampers — Normally Closed

D. Electric Motors: Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.

1. Comply with requirements in Division 23, Common Motor Requirements for HVAC Equipment.

2. Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.

3. Nonspring-Return Motors for Valves Larger Than NPS 2-1/2: Size for running torque of 150 in. x lbf and breakaway torque of 300 in. x lbf.

4. Spring-Return Motors for Valves Larger Than NPS 2-1/2: Size for running and breakaway torque of 150 in. x lbf.

5. Nonspring-Return Motors for Dampers Larger Than 25 Sq. Ft.: Size for running torque of 150 in. x lbf and breakaway torque of 300 in. x lbf.

6. Spring-Return Motors for Dampers Larger Than 25 Sq. Ft.: Size for running and breakaway torque of 150 in. x lbf.

E. Pneumatic Valve Operators: Rolling-diaphragm, spring-loaded, piston type with spring range as required and start-point adjustment and positioning relay. Operator shall maintain full shutoff at maximum pump differential pressure.

F. Pneumatic Damper Operators: Rolling-diaphragm, piston type with adjustable stops and spring return, sized to operate with sufficient reserve power to provide smooth modulating action or two-position action. Where actuators operate in sequence, provide pilot positioners.

1. Pilot Positioners: With the following characteristics:
    a. Start Point: Adjustable from 2 to 12 psig.
    b. Operating Span: Adjustable from 5 to 13 psig.
    c. Linearity: Plus or minus 10 percent of output signal span.
    d. Hysteresis: 3 percent of span.
    e. Response: 0.25-psig input change.
    f. Maximum Pilot Signal Pressure: 20 psig.
    g. Maximum Control Air-Supply Pressure: 60 psig.
2. Actuator Housing: Molded or die-cast zinc or aluminum. Terminal unit actuators may be high-impact plastic with ambient temperature rating of 50 to 140 deg F unless located in return-air plenums.
3. Inlet-Vane Operators: High pressure, with pilot positioners.

G. Acceptable Mfr: Belimo, Schneider Electric, Bray

2.28 CONTROL VALVES

A. Manufacturers:

1. Danfoss Inc.; Air Conditioning & Refrigeration Div.
2. Erie Controls.
3. Hayward Industrial Products, Inc.
4. Magnatrol Valve Corporation.
5. Neles-Jamesbury.
6. Parker Hannifin Corporation; Skinner Valve Division.
7. Pneuline Controls.
8. Sauter Controls Corporation.
9. Belimo
10. Schneider Electric
11. Bray

2.29 AUTOMATIC CONTROL VALVES

A. All automatic control valves shall meet the following requirements:

1. Fully proportioning.
2. Capable of operating at varying rates of speed to correspond to the exact dictates of the controllers and variable load requirements.
3. Body pressure rating and connection type construction shall conform to piping and fittings in which the valve is to be installed and to the valve schedules.
4. Control valves 2” and smaller shall have screwed connections.
5. Control valves larger than 2-1/2” shall have flanged connections.
6. Two-position valves shall be quick opening type with the following characteristics:
   a. Valves shall have replaceable seat, plug, or disc.
   b. Valves shall be line size.
   c. Valve body shall be bronze, cast iron, forged brass, or red brass.
   d. Ball valve shall have stainless steel stem, stainless steel ball, and PTFE seats.
   e. Globe valve shall have stainless steel stem and single stainless steel seat.
   f. The pressure drop shall not exceed 10-20% of the piping system pressure differential, leaving the other 80-90% for the load and piping connections.
   g. Two-Way Valve
      (1) Valve actuator and trim shall provide close-off (differential) pressure ratings greater than or equal to 150% of the total system (pump) head.

B. Water Control Valves: Chilled water, hot water

1. Modulating control valves shall have the following characteristics:
   a. Valve shall be one size below pipe size.
   b. Valve shall have replaceable seat, plug, or disc.
   c. Equal percentage flow characteristic (characterized ball or globe type valves).
   d. Valve body shall be bronze, cast iron, forged brass or red brass.
   e. Ball valve shall have stainless steel stem, stainless steel ball, and PTFE seats.
   f. Globe valve shall have stainless steel steam and single stainless steel seat.
   g. Two-Way Valve
      (1) Calculate Cv based upon maximum design flow and a pressure drop equal to the pressure drop through the coil with a maximum of 5 psi (35 kPa).

(2) Valve actuator and trim shall provide close-off (differential) pressure ratings greater than or equal to 150% of the total system (pump) head.

h. Pressure Independent Control Valves

(1) All hot water control valves shall be pressure independent control valves

(2) Acceptable Mfr: Belimo or Schneider Electric

i. Differential Pressure Bypass Valve

(1) Calculate Cv based upon 80% of the pump flow for a constant volume system or flow provided by pump at minimum speed for a variable volume system and a pressure drop shall be equal to 50% of the total dynamic head. If a valve is being used as a differential pressure bypass valve and chiller minimum flow valve, calculate the Cv based on the minimum flow required by the chiller.

(2) Valve actuator and trim shall provide close-off (differential) pressure ratings greater than or equal to 150% of the total system (pump) head.

j. Chiller Minimum Flow Valve

(1) Calculate Cv based upon flow required by chiller and pressure drop equal to that across chiller.

(2) Valve actuator and trim shall provide close-off (differential) pressure ratings greater than or equal to 150% of the total system (pump) head.

C. Steam Control Valves

1. Control valves shall be globe type with linear flow characteristic.
2. Valves shall have replaceable seat or plug.
3. Valve body shall be bronze, cast iron, or brass.
4. Globe valves shall have stainless steel stem, single stainless steel seat, and stainless steel plug. 5. Sizing:

   a. Two-position service: valve shall be line size with maximum pressure drop equal to 10-20% of inlet pressure (psig).
   b. Modulating service at 15 psig (100 kPa) or less: Calculate Cv based upon maximum flow and pressure drop equal to 80% of inlet pressure (psig) or as required to provide design inlet pressure to coil.
   c. Modulating service at 16-50 psig (101-350 kPa): Calculate Cv based upon maximum flow and pressure drop equal to 42% of inlet pressure (psig) or as required to provide design inlet pressure to coil.

d. Modulating service at over 50 psig (350 kPa): Calculate Cv based upon maximum flow and pressure drop as scheduled on drawings or as required to provide design inlet pressure to coil.

b. Close-off (differential) pressure rating: Valve actuator and trim shall provided minimum close-off pressure rating equal to 150% of operating (inlet) pressure.

c. Whenever the steam flow rate requires a single valve larger than 2 ½", provide two (2) valves in parallel, sized for 1/3, 2/3 capacity, operating sequentially.

D. Provide one (1) control valve for each preheat or heating coil at a minimum.

E. Control valves shall be Belimo, Honeywell, Johnson Controls, Bray, Schneider Electric, Siemens or pre-approved equal.

F. All valve actuators shall meet the following requirements:

1. All valve actuation shall be electric. Pneumatic actuation is not acceptable.
2. Valve actuator shall be by same manufacturer as valve body unless pre-approved.
3. Valve actuators shall:
    a. Be quiet in operation.
    b. Provide smooth modulation at design flow and pressure conditions.
    c. Be capable of operating in sequence with other valves and/or damper actuators when required by the sequence of operation.
    d. Be sized to close against a differential pressure equal to the design pump head plus 15%. Where pressure and flow combinations exceed ratings for commercial valves and actuators, industrial class valves and actuators shall be provided.
    e. Valve actuators shall fail-safe in either the normally open or normally closed position in the event of power failure, signal failure or compressed air failure. Fail Safe positions are as follows:
        (1) Air-Handling Unit Preheat Valves — Fail Open
        (2) Air-Handling Unit Cooling Valves — Fail Closed
        (3) Differential Pressure Bypass Valves — Fail-In-Place
        (4) Duct-mounted Reheat Coil Valves — Fail Closed
4. Incremental Electronic Actuator for Terminal Equipment Valve Actuation
    a. Incremental actuators shall be allowed for terminal equipment only.
    b. Actuators shall be proportional, electronic, direct-coupled actuators used for modulating service. Actuators shall be equipped with metal housings and visual stroke indicators.
    c. Actuators shall be equipped with a permanent manual adjustment.
    d. Minimum Torque: 35" lb.

e. Operating Voltage: 24 VAC.

f. Input Signal: 3-wire floating, 0 – 10 VDC or 4 – 20 mA.

g. Frequency: 50 – 60 Hz.

h. Power Consumption: 1.5VA maximum.

i. Spring Return Time: 20 sec maximum.

j. Spring return position should be field adjustable with a switch.

k. Nominal Force: 90lb Minimum.

l. Stroke: 7/32" (5.5mm) maximum.

m. For use when the maximum media temperature is 230°F.

2.30 BUTTERFLY CONTROL VALVES (CHILLED WATER)

A. All butterfly control valves, where shown on the drawings or specified herein, shall be butterfly type with lug ends and shall be furnished with electric actuators.

B. The valve shall meet the following minimum requirements:

1. Valve body: Carbon steel.
2. Valve disc: 316 stainless steel.
3. Valve shaft: 17-4ph stainless shaft.
4. Valve seat: RTFE.
5. Bubble-tight closure at 285 psi or the required differential pressure across the disc.
6. Maximum system operating temperature: minimum of 250ºF.
7. Valves shall be full-bodied, full lug type only (Wafer type or semi-lugged valves will not be permitted).
8. Valves shall be bolted from both ends of the flanges.
9. Valve shall be manufactured by Bray, Belimo, Schneider Electric, Vanessa, Jamesbury or pre-approved equal.

C. All valve actuators shall be electric type and shall meet the following minimum requirements:

1. Input: Modulating actuators require 4 – 20 mA or 0 – 10 VDC.
2. Gear housing material: Cast iron with double reduction type gear reduction consisting of worm and helical gearing.
3. Worm gear: Alloy bronze.
4. Worm: Alloy steel.
5. Helical gears: Heat-treated steel.
6. Seal materials shall be Viton.
7. Temperature rating shall be -20° – 150ºF.
8. Actuator shall be provided with a manually operated handwheel for overriding actuator position.

9. Actuator shall include a speed control device (adjustable) to prevent the valve from too rapid a closure rate.
10. Actuator shall have an external position indicator and open/close end switches.
11. Actuator motor shall meet the following minimum requirements:
    a. Singlephase, 115V type.
    b. Nominal duty of 15min.
    c. Dynamic torque nominal 20% of start torque.
    d. Class B standard insulation.
    e. Maximum current of 3A.
    f. 120 VAC heater.
    g. Limit switch shall be gear driven.
    h. Snap-acting switch with 16 contacts rated at 600V 6A resistive.
    i. 60A inrush at 120 VAC.
12. Actuator shall be manufactured by Limitorque, Bray or pre-approved equal.

D. Control Valves: Factory fabricated, of type, body material, and pressure class based on maximum pressure and temperature rating of piping system, unless otherwise indicated.

E. Hydronic system globe valves shall have the following characteristics:

1. NPS 2 and Smaller: Class [**125**] [**250**] bronze body, bronze trim, rising stem, renewable composition disc, and screwed ends with backseating capacity repackable under pressure.
2. NPS 2-1/2 and Larger: Class 125 iron body, bronze trim, rising stem, plug-type disc, flanged ends, and renewable seat and disc.
3. Internal Construction: Replaceable plugs and stainless-steel or brass seats.
    a. Single-Seated Valves: Cage trim provides seating and guiding surfaces for plug on top and bottom.
    b. Double-Seated Valves: Balanced plug; cage trim provides seating and guiding surfaces for plugs on top and bottom.
4. Sizing: 3-psig maximum pressure drop at design flow rate or the following:
    a. Two Position: Line size.
    b. Two-Way Modulating: Either the value specified above or twice the load pressure drop, whichever is more.
    c. Three-Way Modulating: Twice the load pressure drop, but not more than value specified above.
5. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics.
6. Close-Off (Differential) Pressure Rating: Combination of actuator and trim shall provide minimum close-off pressure rating of 150 percent of total system (pump) head for two-

way valves and 100 percent of pressure differential across valve or 100 percent of total system (pump) head.

F. Steam system globe valves shall have the following characteristics:

1. NPS 2 and Smaller: Class 125 bronze body, bronze trim, rising stem, renewable composition disc, and screwed ends with backseating capacity repackable under pressure.
2. NPS 2-1/2 and Larger: Class 125 iron body, bronze trim, rising stem, plug-type disc, flanged ends, and renewable seat and disc.
3. Internal Construction: Replaceable plugs and stainless-steel seats.
    a. Single-Seated Valves: Cage trim provides seating and guiding surfaces for plug on top and bottom of guided plugs.
    b. Double-Seated Valves: Balanced plug; cage trim provides seating and guiding surfaces for plugs on top and bottom of guided plugs.
4. Sizing: For pressure drop based on the following services:
    a. Two Position: 20 percent of inlet pressure.
    b. Modulating 15-psig Steam: 80 percent of inlet steam pressure.
    c. Modulating 16- to 50-psig Steam: 50 percent of inlet steam pressure.
    d. Modulating More Than 50-psig Steam: As indicated.
5. Flow Characteristics: Modified linear characteristics.
6. Close-Off (Differential) Pressure Rating: Combination of actuator and trim shall provide minimum close-off pressure rating of 150 percent of operating (inlet) pressure.

G. Butterfly Valves: 200-psig, 150-psig maximum pressure differential, ASTM A 126 cast-iron or ASTM A 536 ductile-iron body and bonnet, extended neck, stainlesssteel stem, field-replaceable EPDM or Buna N sleeve and stem seals.

1. Body Style: Wafer.
2. Disc Type: Nickel-plated ductile iron, Aluminum bronze, Elastomer-coated ductile iron, Epoxy-coated ductile iron.
3. Sizing: 1-psig maximum pressure drop at design flow rate.

H. Terminal Unit Control Valves: Bronze body, bronze trim, two or three ports as indicated, replaceable plugs and seats, and union and threaded ends.

1. Rating: Class 125 for service at 125 psig and 250 deg F operating conditions.
2. Sizing: 3-psig maximum pressure drop at design flow rate, to close against pump shutoff head.
3. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics.

I. Self-Contained Control Valves: Bronze body, bronze trim, two or three ports as indicated, replaceable plugs and seats, and union and threaded ends.

1. Rating: Class 125 for service at 125 psig and 250 deg F operating conditions.
2. Thermostatic Operator: Liquid-filled integral sensor with integral adjustable dial.

2.31 DAMPERS (TO BE PROVIDED BY THE MECHANICAL CONTRACTOR)

A. Manufacturers:

1. Air Balance Inc.
2. Don Park Inc.; Autodamp Div.
3. TAMCO (T. A. Morrison & Co. Inc.).
4. United Enertech Corp.
5. Vent Products Company, Inc.

B. Dampers: AMCA-rated, parallel or opposed-blade design; 0.108-inch- minimum thick, galvanized-steel or 0.125-inch- minimum thick, extruded-aluminum frames with holes for duct mounting; damper blades shall not be less than 0.064-inch- thick galvanized steel with maximum blade width of 8 inches and length of 48 inches.

1. Secure blades to 1/2-inch- diameter, zinc-plated axles using zinc-plated hardware, with oil-impregnated sintered bronze blade bearings, blade-linkage hardware of zinc-plated steel and brass, ends sealed against spring-stainless-steel blade bearings, and thrust bearings at each end of every blade.
2. Operating Temperature Range: From minus 40 to plus 200 deg F.
3. Edge Seals, Standard Pressure Applications: Closed-cell neoprene.
4. Edge Seals, Low-Leakage Applications: Use inflatable blade edging or replaceable rubber blade seals and spring-loaded stainless-steel side seals, rated for leakage at less than 10 cfm per sq. ft. of damper area, at differential pressure of 4-inch wg when damper is held by torque of 50 in. x lbf; when tested according to AMCA 500D.

2.32 AIR SUPPLY

A. Manufacturers:

1. Drainview Products.
2. Pneuline Controls.

B. Control and Instrumentation Tubing: Copper tubing complying with ASTM B 88, Type K or ASTM B 280 Type ACR.

1. Fittings: Cast-bronze solder fittings complying with ASME B16.18; or wrought-copper solder fittings complying with ASME B16.22, except forged-brass compression-type fittings at connections to equipment.
2. Joining Method: Soldered or brazed.

C. Control and Instrumentation Tubing: ASTM D 2737 Type FR plenum-rated polyethylene, flame-retardant, nonmetallic tubing rated for 30 psig and ambient temperature range of 10 to 150 deg F with flame-retardant harness for multiple tubing.

1. Fittings: Compression or push-on polyethylene fittings.

D. Tank: ASME storage tank with drain test cock, automatic moisture removal trap, tank relief valve, and rubber-cork vibration isolation mounting pads.

E. Duplex Air Compressor: Capacity to supply compressed air to temperature-control system.

1. Pressure control with adjustable electric contacts, set to start and stop both compressors at different pressures.

2. Electrical alternation set with motor starters and disconnect to operate compressors alternately or on time schedule.

F. Simplex Air Compressor: Tank-mounting compressor with capacity to supply compressed air to temperature-control system, with starter and disconnect.

1. Pressure control with adjustable electric contacts, set to start and stop compressor. G.

Compressor Type: Reciprocating or Scroll.

H. Size compressor and tank to operate compressor not more than 20 minutes during a 60-minute period.

I. Compressor Accessories: Low-resistance intake-air filter, and belt guards.

J. System Accessories: Air filter rated for 97 percent efficiency at rated airflow, and combination filter/pressure-reducing station or separate filter and pressurereducing station.

K. Refrigerated Air Dryer: Self-contained, refrigerated air dryer complete with heat exchangers, moisture separator, internal wiring and piping, and with manual bypass valve.

1. Heat Exchangers: Air-to-refrigerant coils with centrifugal-type moisture separator and automatic trap assembly.

2. Refrigeration Unit: Hermetically sealed, operating to maintain dew point of 13 deg F at 20 psig, housed in steel cabinet with access door and panel.

3. Accessories: Air-inlet temperature gage, air-inlet pressure gage, on-off switch, hightemperature light, power-on light, refrigerant gage on back, air-outlet temperature gage, air-outlet pressure gage, and with contacts for remote indication of power status and hightemperature alarm.

L. Desiccant Dryer: Obtains dew point in pneumatic air piping between compressor and tank at least 15 deg F below inlet-air dew point at design conditions.

M. Pressure Gages: Black letters on white background, 2-1/2 inches in diameter, flush or surface mounting, with front calibration screw to match sensor, and having a graduated scale in psig.

N. Instrument Pressure Gages: Black letters on white background, 1-1/2 inches in diameter, stem mounted, with suitable dial range.

O. Diaphragm Control and Instrument Valves: 1/4-inch forged-brass body with reinforced polytetrafluoroethylene diaphragm, stainless-steel spring, and colorcoded phenolic handle.

P. Gage Cocks: Tee or level handle, bronze, rated for 125 psig.

Q. Relays: For summing, reversing, and amplifying highest or lowest pressure selection; with adjustable I/O ratio.

R. Switches: With indicating plates and accessible adjustment; calibrated and marked.

S. Pressure Regulators: Zinc or aluminum castings with elastomeric diaphragm, balanced construction to automatically prevent pressure buildup, and producing flat reduced-pressure curve.

T. Particle Filters: Zinc or aluminum castings with 97 percent filtration efficiency at rated airflow, quick-disconnect service devices, and aluminum or plastic bowl with metal guard and manual drain cock.

U. Combination Filter/Regulators: Zinc or aluminum castings with elastomeric diaphragm, balanced construction to automatically prevent pressure buildup, and producing flat reduced-pressure curve; with threaded pipe connections, quickdisconnect service devices, and aluminum or plastic bowl with metal guard and manual drain cock.

V. Airborne Oil Filter: Filtration efficiency of 99.9 percent for airborne lubricating oil particles of 0.025 micron or larger.

W. Pressure Relief Valves: ASME rated and labeled.

1. High Pressure: Size for installed capacity.
2. Low Pressure: Size for installed capacity of pressure regulators and set at 20 percent above low pressure.

X. Pressure-Reducing Stations: Two parallel pressure regulators.

2.33 CONTROL CABLE

A. Electronic and fiber-optic cables for control wiring are specified in Division 27, Communications Horizontal Cabling.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that conditioned power supply is available to control units and operator workstation.

B. Verify that pneumatic piping and duct-, pipe-, and equipment-mounted devices are installed before proceeding with installation.

3.2 INSTALLATION

A. Install software in control units and operator workstation(s). Implement all features of programs to specified requirements and as appropriate to sequence of operation.

B. Connect and configure equipment and software to achieve sequence of operation specified.

C. Verify location of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. Install devices 48 inches above the floor.

1. Install averaging elements in ducts and plenums in crossing or zigzag pattern. D.

Install guards on thermostats in the following locations:

1. Where indicated on the mechanical drawings.

E. Install automatic dampers according to Division 23, Air Duct Accessories.

F. Install damper motors on outside of duct in warm areas, not in locations exposed to outdoor temperatures.

G. Install labels and nameplates to identify control components according to Division 23, Identification for HVAC Piping and Equipment.

H. Install hydronic instrument wells, valves, and other accessories according to Division 23, Hydronic Piping.

I. Install steam and condensate instrument wells, valves, and other accessories according to Division 23, Steam and Condensate Heating Piping.

J. Install refrigerant instrument wells, valves, and other accessories according to Division 23, Refrigerant Piping.

K. Install duct volume-control dampers according to Division 23, Metal Ducts and Division 23, Nonmetal Ducts.

L. Install electronic and fiber-optic cables according to Division 27, Communications Horizontal Cabling.

3.3 PNEUMATIC PIPING INSTALLATION

A. Install piping in mechanical equipment rooms inside mechanical equipment enclosures, in pipe chases, or suspended ceilings with easy access.

1. Install copper tubing with maximum unsupported length of 36 inches, for tubing exposed to view.

2. Install polyethylene tubing in metallic raceways or electrical metallic tubing. Electrical metallic tubing materials and installation requirements are specified in Division 26, Raceways and Boxes for Electrical Systems.

B. Install terminal single-line connections, less than 18 inches in length, with copper or polyethylene tubing run inside flexible steel protection.

C. In concealed locations such as pipe chases and suspended ceilings with easy access, install copper, polyethylene bundled and sheathed, polyethylene tubing in electrical metallic tubing. Electrical metallic tubing materials and installation requirements are specified in Division 26, Raceways and Boxes for Electrical Systems.

D. In concrete slabs, furred walls, or ceilings with no access, install copper or polyethylene tubing in electrical metallic tubing or vinyl-jacketed polyethylene tubing.

1. Protect embedded-copper and vinyl-jacketed polyethylene tubing with electrical metallic tubing extending 6 inches above finished slab and 6 inches into slab. Pressure test tubing before and after pour for leak and pinch.

2. Install polyethylene tubing in electrical metallic tubing extending 6 inches above floor line; pull tubing into electrical metallic tubing after pour.

E. Install tubing with sufficient slack and flexible connections to allow for vibration of piping and equipment.

F. Purge tubing with dry, oil-free compressed air before connecting control instruments.

1. Bridge cabinets and doors with flexible connections fastened along hinge side; protect against abrasion. Tie and support tubing.

G. Number-code or color-code control air piping for future identification and service of control system, except local individual room control tubing.

H. Pressure Gages or Test Plugs: Install on branch lines at each receiver controller and on signal lines at each transmitter, except individual room controllers.

3.4 ELECTRICAL WIRING AND CONNECTION INSTALLATION

A. Install raceways, boxes, and cabinets according to Division 26, Raceways and Boxes for Electrical Systems.

B. Install building wire and cable according to Division 26, Low-Voltage Electrical Power Conductors and Cables.

C. Install signal and communication cable according to Division 27, Communications Horizontal Cabling.

1. Install, connect and wire the items included under this Section. This work includes providing required conduit, wire, fittings and related wiring accessories.
2. All exposed wiring and wiring in mechanical equipment rooms shall be installed in EMT conduit.
3. Plenum rated cable shall be acceptable in ceilings, walls and raised floors.
4. All wiring located outside shall be installed in rigid conduit, seal tite or EMT with compression fittings.
5. Conceal cable, except in mechanical rooms and areas where other conduit and piping are exposed.
6. Install cable in raceway.
7. Bundle and harness multiconductor instrument cable in place of single cables where several cables follow a common path.
8. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.
9. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.
10. Install wire and cable with sufficient slack and flexible connections to allow for vibration of piping and equipment.

D. Connect manual-reset limit controls independent of manual-control switch positions. Automatic duct heater resets may be connected in interlock circuit of power controllers.

E. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.

F. Wires and cables shall be as follows:

1. Single Conductor (120 VAC): Type THWN 12AWG stranded copper with 600V insulation.

G. Primary and Secondary Communications Network Cabling

1. Primary network shall be Ethernet based and shall utilize CAT5, CAT6 or fiber optic cable. All wiring runs longer than 300’ shall utilize fiber optic cable.
2. Cable shall be of type recommend by the DDC System Manufacturer and 20AWG at a minimum.
3. Cable shall be shielded.
4. All fiber optic cabling shall be 62.5/125uM multi-mode graded index cable. Industry standard ST style connectors shall be used, with a hot melt or glue and polish termination. Use of mechanical crimp type connectors is not acceptable. All fiber runs shall have a minimum of 100% spare fibers within the cable run.

H. Room Sensor Cabling

1. Cable shall consist of copper conductors not less than No. 24 AWG. or CAT 6

I. Cables for 120 VAC wiring and low level signal wiring (i.e., 4 – 20 mA analog) shall always be run in separate raceways.

3.5 CONNECTIONS

A. Connect manual-reset limit controls independent of manual-control switch positions. Automatic duct heater resets may be connected in interlock circuit of power controllers.

B. Connect HOA selector switches to override automatic interlock controls when switch is in hand position. C. Ground equipment.

3.6 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove and replace malfunctioning units and retest.
2. Test and adjust controls and safeties.
3. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
4. Pressure test control air piping at 30 psig or 1.5 times the operating pressure for 24 hours, with maximum 5-psig loss.

5. Pressure test high-pressure control air piping at 150 psig and low-pressure control air piping at 30 psig for 2 hours, with maximum 1-psig loss.
6. Test calibration of [**pneumatic**] [**electronic**] controllers by disconnecting input sensors and stimulating operation with compatible signal generator.
7. Test each point through its full operating range to verify that safety and operating control set points are as required.
8. Test each control loop to verify stable mode of operation and compliance with sequence of operation. Adjust PID actions.
9. Test each system for compliance with sequence of operation.
10. Test software and hardware interlocks. C. DDC Verification:

1. Verify that instruments are installed before calibration, testing, and loop or leak checks.
2. Check instruments for proper location and accessibility.
3. Check instrument installation for direction of flow, elevation, orientation, insertion depth, and other applicable considerations.
4. Check instrument tubing for proper fittings, slope, material, and support.
5. Check installation of air supply for each instrument.
6. Check flow instruments. Inspect tag number and line and bore size, and verify that inlet side is identified and that meters are installed correctly.
7. Check pressure instruments, piping slope, installation of valve manifold, and selfcontained pressure regulators.
8. Check temperature instruments and material and length of sensing elements.
9. Check control valves. Verify that they are in correct direction.
10. Check air-operated dampers. Verify that pressure gages are provided and that proper blade alignment, either parallel or opposed, has been provided.
11. Check DDC system as follows:
    a. Verify that DDC controller power supply is from emergency power supply, if applicable.
    b. Verify that wires at control panels are tagged with their service designation and approved tagging system.
    c. Verify that spare I/O capacity has been provided.
    d. Verify that DDC controllers are protected from power supply surges.

D. Replace damaged or malfunctioning controls and equipment and repeat testing procedures.

3.7 ADJUSTING

A. Calibrating and Adjusting:

1. Calibrate instruments.

2. Make three-point calibration test for both linearity and accuracy for each analog instrument.
3. Calibrate equipment and procedures using manufacturer's written recommendations and instruction manuals. Use test equipment with accuracy at least double that of instrument being calibrated.
4. Control System Inputs and Outputs:
    a. Check analog inputs at 0, 50, and 100 percent of span.
    b. Check analog outputs using milliampere meter at 0, 50, and 100 percent output.
    c. Check digital inputs using jumper wire.
    d. Check digital outputs using ohmmeter to test for contact making or breaking.
    e. Check resistance temperature inputs at 0, 50, and 100 percent of span using a precision-resistant source.
5. Flow:
    a. Set differential pressure flow transmitters for 0 and 100 percent values with 3-point calibration accomplished at 50, 90, and 100 percent of span.
    b. Manually operate flow switches to verify that they make or break contact.
6. Pressure:
    a. Calibrate pressure transmitters at 0, 50, and 100 percent of span.
    b. Calibrate pressure switches to make or break contacts, with adjustable differential set at minimum.
7. Temperature:
    a. Calibrate resistance temperature transmitters at 0, 50, and 100 percent of span using a precision-resistance source.
    b. Calibrate temperature switches to make or break contacts.
8. Stroke and adjust control valves and dampers without positioners, following the manufacturer's recommended procedure, so that valve or damper is 100 percent open and closed.
9. Stroke and adjust control valves and dampers with positioners, following manufacturer's recommended procedure, so that valve and damper is 0, 50, and 100 percent closed.

10. Provide diagnostic and test instruments for calibration and adjustment of system.

11. Provide written description of procedures and equipment for calibrating each type of instrument. Submit procedures review and approval before initiating startup procedures. B. Adjust initial temperature and humidity set points.

C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to **three** visits to Project during other than normal occupancy hours for this purpose.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain HVAC instrumentation and controls. Refer to Division 01, Demonstration and Training.

3.9 TRAINING

A. The BMS contractor shall provide competent instructors to give full instruction to designated personnel in the adjustment, operation and maintenance of the system installed rather than a general training course. Instructors shall be thoroughly familiar with all aspects of the subject matter they are to teach. All training shall be held during normal work hours of 8:00 a.m. to 4:30 p.m. weekdays.

B. Provide sixteen (16) hrs of training for Owner's operating and maintenance personnel. All training shall be on-site training. Videotape all sessions and edit each session to 1-hour DVDs. Turn over two (2) copies each unedited and edited DVD to the Owner. Training shall include:

1. Explanation of drawings, operators and maintenance manuals.
2. Walk-through of the job to locate all control components.
3. Operator workstation and peripherals.
4. DDC Controller operation/function.
5. Operator control functions including graphic generation, if design includes color graphics and field panel programming.
6. Explanation of adjustment, calibration and replacement procedures.

A. Since the Owner may require personnel to have more comprehensive understanding of the hardware and software, additional training must be available from the Contractor. If the Owner requires such training, it will be contracted at a later date. Provide description of available local and factory customer training. Provide costs associated with performing training at an off-site classroom facility and detail what is included in the manufacturer's standard pricing such as transportation, meals, etc.

3.10 ON-SITE ASSISTANCE

A. Occupancy Adjustments: Within 1 year of date of Substantial Completion, provide up to three (3) 4-Hour Project-site visits, when requested by Owner, to adjust and calibrate components and to assist Owner's personnel in making program changes and in adjusting sensors and controls to suit actual conditions.

3.11 RECORD DOCUMENTATION

A. Operation and Maintenance Manuals

1. Three (3) copies of the Operation and Maintenance Manuals shall be provided to the Owner's Representative upon completion of the project. The entire Operation and Maintenance Manual shall be furnished on Compact Disc media and include the following for the BMS provided:

a. Table of contents.

b. As-built system record drawings. Record drawings shall represent the asbuilt condition of the system and incorporate all information supplied with the approved submittal.

c. Manufacturers product data sheets or catalog pages for all products including software.

d. System Operator's manuals.

e. Archive copy of all site-specific databases and sequences.

f. BMS network diagrams.

g. Interfaces to all third-party products and work by other trades.

B. The Operation and Maintenance Manual CD shall be self-contained and include all necessary software required to access the product data sheets. A logically organized table of contents shall provide dynamic links to view and print all product data sheets. Viewer software shall provide the ability to display, zoom and search all documents.

3.12 WARRANTY

A. The BMS shall include a one (1) year parts and labor warranty to begin upon system acceptance that covers the entire system to correct any operational issues at no additional cost to the Owner. The warranty shall cover adjustment

and calibration of components and assistance to building personnel in making program changes and in adjusting sensors and controls to suit actual conditions. System acceptance shall be determined by the Owner.

B. During the warranty period, the Contractor shall guarantee the following in a form satisfactory to the Owner:

1. All work installed will be free from any and all defects in workmanship and or materials.
2. All devices will operate as per the capacities and performance characteristics specified.
3. The systems shall operate without malfunction.

C. Maintain an adequate supply of materials within 100 miles of the Project site

D. Provide specific warranty details as part of the proposal and submittal.

END OF SECTION

SECTION 230993
SEQUENCES OF OPERATION

PART 1 - GENERAL

1.0 RELATED DOCUMENTS

A. The following documents apply to all required work for the Project:

1. Contract Drawings
2. Specifications (Including Section 230900 – Instrumentation and Control for HVAC)
3. General Conditions
4. Addendum 5. Contract.

1.1 GENERAL

A. General
1. This contractor shall coordinate with drawing and details. All necessary points shall be added to conform to the intent of sequence of operation described below.
2. Reference Instrumentation and Control for HVAC specification section 230900
3. Existing RUMC Campus BMS Vendor– EcoStuxure by Albireo Energy- Contact Anthony Nobile (732-407-6082)

1.2 SEQUENCES OF OPERATIONS

A. AHU-1
1. The BMS contractor shall provide all the required DDC controls and control end devices for a fully functional system.
2. Safeties:
a. A low suction air pressure switch located upstream of the supply fans and downstream of the closest damper shall stop the supply fans and return fans when duct pressure decreases below 0.5 inches (adj.). A high discharge air pressure switch located downstream of the supply fans and upstream of the closest damper shall stop the supply fans and return fans when duct pressure exceeds 2.5 inches (adj.). The pressure switches shall be wired directly to the VFDs and shall be monitored by the BMS.
b. A low suction air pressure switch located upstream of the return fan and downstream of the closest damper shall stop the supply fans and return fans when duct pressure decreases below 0.5 inches (adj.). A high discharge air pressure switch located downstream of the return fan and upstream of the closest damper shall stop the supply fans and return fans when duct pressure exceeds 2.5 inches (adj.). The pressure switches shall be wired directly to the VFDs and shall be monitored by the BMS.
c. Freezestats installed downstream of the steam preheat coil and upstream of the cooling coil shall de-energize the unit upon sensing a temperature

below 38 deg F (adj), and shall be monitored by the BMS. Provide multiple freezestats as required for adequate coverage.

d. The BMS shall monitor the pre-filter status via a differential pressure sensor and final-filter status via a differential pressure sensor.

3. Air Flow Monitoring:
   a. Each supply fan and return fan will be provided with piezo rings by the AHU Manufacturer.
   b. The BMS shall provide and install a differential pressure sensor for each supply fan and return fan to individually calculate each supply fan's air flow and each return fan's airflow.
   c. The BMS shall will then calculate the total supply airflow and total return airflow for the AHU.
   d. The BMS will provide and install a duct mounted outside air flow measuring station for monitoring outside air at the AHU.
4. Occupied Mode:
   a. The air handling unit shall start/stop by the BMS through a BMS timeclock schedule or a manual command from the BMS.
   b. Upon a command to start, the outside air damper shall open to minimum position. The outside air damper shall modulate to maintain outside air flow minimum CFM setpoint (as measured by the outside air flow station).
   c. Once the outside air damper is commanded open, the supply fan VFDs and return fan VFDs shall start unloaded and slowly ramp up to speed as required. In the occupied mode, the supply fan VFDs and return fan VFDs shall run continuously.
      1) All supply fan VFDs shall be controlled in unison during normal operation. If any supply fan VFD fails at anytime, an alarm shall be generated at the BMS, and the remaining supply fan VFDs will continue to operate to maintain setpoint.
         a) Each supply fan VFD will be wired to independent BMS points on the BMS DDC controller.
         b) Reference the mechanical schedules for the quantity of AHU supply fan VFDs.
      2) All return fan VFDs shall be controlled in unison during normal operation. If any return fan VFD fails at anytime, an alarm shall be generated at the BMS, and the remaining supply fan VFDs will continue to operate to maintain setpoint.
         a) Each return fan VFD will be wired to independent BMS points on the BMS DDC controller.
         b) Reference the mechanical schedules for the quantity of AHU return fan VFDs.
   d. The supply fans VFDS shall be controlled in unison to maintain the supply static pressure setpoint of 1.5 inches (adj.), as sensed at a point 2/3 downstream of the supply fan.
      1) The BMS shall reset the supply air static pressure setpoint every (10) minutes (adj) in .05" WC increments (adj), based on the VAV boxes damper position. If none of the dampers are commanded to 80% or more open for 10 minutes (adj), reduce the static pressure setpoint. If one or two dampers are commanded to 95% open or

more for 10 minutes (adj) maintain the static pressure setpoint. If three or more dampers are commanded to 95% open or more for 10 minutes (adj), increase the static pressure setpoint.

e. The return fans VFDs shall be controlled in unison to maintain the return airflow setpoint. The return airflow setpoint shall be calculated as the measured supply airflow minus a differential airflow. The differential airflow shall be determined by the tab contractor, accounting for exhaust airflows and building pressurization requirements

f. The BMS shall monitor all available points through each fans' VFD manufacturer BACnet interface.

g. Demand Control Ventilation: The BMS shall monitor the return CO2 sensor served by the associated AHU. The BMS shall reset the outdoor airflow set point to maintain a maximum 450 ppm differential between each return CO2 and the master outdoor air CO2 transmitter. On an increase in CO2 differential above set point, the BMS shall increase the outdoor airflow rate to maintain set point. On a decrease in CO2 differential below set point, the reverse shall occur. The minimum outdoor airflow set point reset shall be limited to a minimum and maximum design airflow. Reset limits shall be operator-adjustable. The operator shall be capable of enabling/disabling the automatic reset at any time from the workstation.

h. Mixed Air Low Limit: The initial damper opening rate shall be limited to 2% per minute (adj.) until the damper has reached its minimum ventilation position. The outside air damper shall modulate to a position less than the minimum damper position if the mixed air temperature drops below 50.0 deg. F (adj.). If the mixed air temperature sensor fails an alarm shall be annunciated at the BAS and the outside air damper shall return to the minimum position.

i. Economizer shall be available whenever the outside air enthalpy is below setpoint and less than the air handling unit return air enthalpy and disabled when the outside air enthalpy is above the return air enthalpy. If economizer is available and there is a rise in supply air temperature above the supply air temperature setpoint, both the outside air damper and spill air damper shall be modulated to 100% open as necessary to maintain the supply air temperature setpoint. The return air damper shall modulate closed as the outside air damper and spill air damper modulate open. If the outside air damper is 100% open and there is a further rise in temperature above supply air temperature setpoint, the outside air damper shall remain 100% open and the chilled water valve shall modulate open as necessary to maintain the supply air temperature setpoint.

j. Cooling Mode

1) On a call for cooling, the BMS shall modulate the chilled water valve to maintain cooling coil supply air temperature setpoint (adj).

2) The steam preheat valves shall remain closed in cooling mode.

k. Heating Mode:

1) On a call for heating, the BMS will modulate the 1/3rd capacity and 2/3rd capacity steam preheat valves to maintain preheat coil supply air temperature setpoint (adj).
   a) The 1/3rd capacity steam preheat valve will first modulate open to maintain preheat coil supply air temperature setpoint. If the 1/3rd capacity steam preheat valve is fully open, and the preheat coil supply air temperature is still below setpoint, the BMS shall modulate open the 2/3rd capacity steam preheat valve to maintain setpoint.
2) The chilled water valve shall remain closed in heating mode.

l. Humidification Mode
1) The BMS shall modulate open the steam humidifier control valve to maintain return air humidity setpoint (adj).
   a) The return air humidity setpoint shall be reset based on the (2) space relative humidity sensors (one sensor shall be installed in the EP lab, and one sensor shall be installed in the CATH lab).
2) A discharge air humidity sensor shall be installed downstream of the humidifier to limit the discharge humidity to 90% RH (adj). The BMS shall alarm if the discharge humidity exceeds this level.
3) The BMS shall also provide all the low voltage miscellaneous control wiring required for control devices shipped loosed with the humidifier, including, but not limited to, wiring the Mfr air flow switch, and high temperature switch.

5. Unoccupied Mode:
   a. Unoccupied Mode: The chilled water valve, steam preheat 1/3rd and 2/3rd valves and steam humidifier valve shall be closed. The outside air and spill air dampers shall be closed and the return air dampers shall be open. The supply and return fan VFDs shall be commanded off.
   b. If the space temperature or space relative humidity served by the AHU rises above or falls below unoccupied setpoint (adj) for a period of (10) minutes (adj), the AHU shall be started and the controlled as described above until the space temperature and space relative humidity is within unoccupied setpoint for a period of (20) minutes (adj).
      1) During unoccupied mode, the return air dampers shall be fully open with the spill and outside air dampers fully closed, even when the unit is in operation.
6. The BMS shall provide a mixed air temperature sensor for monitoring at the BMS.
7. The BMS shall monitor the return air temperature and humidity and calculate return air enthalpy.
8. The BMS shall utilize the existing global outside air temperature and humidity sensor and calculate outside air enthalpy.
9. The BMS shall monitor a single AHU general fire alarm contact from a fire alarm module located at the AHU.
10. The following shall be displayed and alarmed as necessary at the existing Albireo Energy RUMC BMS:
    a. High pressure safeties status

b. Low pressure safeties status
c. Freezestat status
d. Pre-Filter differential pressure
e. Final-Filter differential pressure
f. Supply fan differential pressure (each fan)
g. Supply fan airflow (calculated for each fan)
h. Return fan differential pressure (each fan)
i. Return fan airflow (calculated for each fan)
j. Supply air total CFM (calculated)
k. Return air total CFM and setpoint (calculated)
l. Outside air CFM and setpoint
m. Supply fan VFD command: 0-100 percent, start/stop, status(cs), alarm (each supply fan VFD)
n. Return fan VFD command: 0-100 percent, start/stop, status(cs), alarm (each return fan VFD)
o. All points available through the VFD BACnet interface (each VFD)
p. Supply air static pressure and setpoint
q. Outside air damper command: 0-100 percent
r. Spill air damper command: 0-100 percent
s. Return air damper command:0-100 percent
t. Steam preheat 1/3rd capacity valve command: 0-100 percent
u. Steam preheat 2/3rd capacity valve command: 0-100 percent
v. Chilled water valve command: 0-100 percent
w. Steam humidifier valve command: 0-100 percent
x. Mixed air temperature
y. Cooling coil supply air temperature and setpoint
z. Preheat coil supply air temperature and setpoint aa. Outside air temperature (existing global point) bb. Outside air humidity (existing global point) cc. Outside air enthalpy (calculated) dd. Return air temperature ee. Return air humidity ff. Return air enthalpy (calculated) gg. Discharge air humidity hh. Space humidity (EP Lab) ii. Space humidity (CATH lab) jj. AHU general fire alarm status

B. Duplex Condensate Pump Unit
1. The duplex condensate pump unit shall be provided with factory mounted and wired controls by the Duplex condensate pump unit Mfr.
2. The BMS shall monitor the common alarm for the duplex condensate pump unit through a dry contact provided by the duplex condensate pump unit Mfr.
3. The BMS shall also provide and wire a current switch to monitor the status of each of the (2) condensate pumps.
4. The following shall be displayed and alarmed as necessary at the existing Albireo Energy RUMC BMS:
   a. Duplex Condensate pump unit common alarm status
   b. Duplex Condensate pump 1 status
   c. Duplex Condensate pump 2 status

C. Filter Bank
1. The BMS shall monitor each Filter bank via a single differential pressure sensor.

2. If the filter bank differential pressure rises above setpoint (adj), an alarm shall be generated at the BMS.
3. The following shall be displayed and alarmed as necessary at the existing Albireo Energy RUMC BMS:
   a. Filter bank differential pressure

D. HEPA Filter Housing
1. The HEPA filter will come equipped with an OEM transmitter in each ceiling panel. The BMS shall monitor each HEPA filter transmitter.
2. If the HEPA filter housing differential pressure rises above setpoint (adj), an alarm shall be generated at the BMS.
3. The following shall be displayed and alarmed as necessary at the existing Albireo Energy RUMC BMS:
   a. PEA Filter Housing differential pressure (per filter transmitter)

E. VAV Boxes with Hot Water Heating
1. The BMS shall control and monitor each VAV box via a BACnet IP DDC controller. Each VAV controller shall be hardwired to the BMS network and shall communicate to the BMS system via BACnet IP communication. Each VAV box shall have a dedicated hardwired space temperature sensor and discharge air temperature sensor.
2. Coordinate factory mounting and wiring of controller, actuator, and transformer with VAV box manufacturer. Provide all controls not provided by Mfr for a complete installation.
3. During occupied mode, as the space temperature increases over occupied setpoint (adj), the pressure independent hot water valve shall be closed, and the supply air damper shall modulate open to maximum CFM position. As the space temperature falls below setpoint, the supply air damper shall modulate to minimum CFM position. If the space temperature is still below setpoint, with the supply air damper at minimum position, the damper shall modulate open to the minimum heating CFM position, and the pressure independent hot water valve shall modulate open to maintain space temperature setpoint.
   a. The BMS shall monitor the discharge temperature of each VAV Box to confirm the hot water heating is functional.
4. During unoccupied mode, the VAV box dampers shall be fully closed and the pressure independent hot water valve shall be closed. If the space temperature falls below unoccupied setpoint, the associated AHU shall be enabled, and the VAV box shall be controlled as described above until the space temperature is above the unoccupied setpoint for a period of (10) min (adj).
5. Space temperature setpoint shall be adjustable at either the space sensor or the BMS workstation.
6. The following shall be displayed and alarmed as necessary at the existing Albireo Energy RUMC BMS:
   a. Space temperature and setpoint
   b. CFM and setpoint
   c. Min & Max CFM
   d. Supply damper command: 0-100%
   e. Pressure independent hot water control valve command: 0-100%
   f. Discharge temperature sensor

F. CAV Boxes with Hot Water Heating

1. The BMS shall control and monitor each CAV box via a BACnet IP DDC controller. Each CAV controller shall be hardwired to the BMS network and shall communicate to the BMS system via BACnet IP communication. Each CAV box shall have a dedicated hardwired space temperature sensor and discharge air temperature sensor.
2. Coordinate factory mounting and wiring of controller, actuator, and transformer with CAV box manufacturer. Provide all controls not provided by Mfr for a complete installation.
3. During occupied mode, the BMS shall control the supply air damper to maintain CFM setpoint. If the space temperature falls below setpoint, the pressure independent hot water valve shall modulate open to maintain space temperature setpoint.
   a. The BMS shall monitor the discharge temperature of each CAV Box to confirm the hot water heating is functional.
4. During unoccupied mode, the CAV box dampers shall be fully closed and the pressure independent hot water valve shall be closed. If the space temperature falls below unoccupied setpoint, the associated AHU shall be enabled, and the CAV box shall be controlled as described above until the space temperature is above the unoccupied setpoint for a period of (10) min (adj).
5. Space temperature setpoint shall be adjustable at either the space sensor or the BMS workstation.
6. The following shall be displayed and alarmed as necessary at the existing Albireo Energy RUMC BMS:
   a. Space temperature and setpoint
   b. CFM and setpoint
   c. Supply damper command: 0-100%
   d. Pressure independent hot water control valve command: 0-100%
   e. Discharge temperature sensor

G. CAV Boxes with Hot Water Heating interlocked with RCAV Boxes (Serving CATH lab and EP lab)

1. The BMS shall control and monitor each CAV box via a BACnet IP DDC controller. Each CAV controller shall be hardwired to the BMS network and shall communicate to the BMS system via BACnet IP communication. Each CAV box shall have a dedicated hardwired space temperature sensor and discharge air temperature sensor.
2. Coordinate factory mounting and wiring of controller, actuator, and transformer with CAV box manufacturer. Provide all controls not provided by Mfr for a complete installation.
   a. The CAV box damper actuators serving the CATH lab and EP lab shall have fast speed actuators, it will not be acceptable to utilize the standard CAV controller's integral actuator.
3. During occupied mode, the BMS shall control the supply air damper to maintain CFM setpoint. If the space temperature falls below setpoint, the pressure independent hot water valve shall modulate open to maintain space temperature setpoint.
   a. The BMS shall monitor the discharge temperature of each CAV Box to confirm the hot water heating is functional.

4. During unoccupied mode, the CAV box dampers shall be fully closed and the pressure independent hot water valve shall be closed. If the space temperature falls below unoccupied setpoint, the associated AHU shall be enabled, and the CAV box shall be controlled as described above until the space temperature is above the unoccupied setpoint for a period of (10) min (adj).
5. Space temperature setpoint shall be adjustable at either the space sensor or the BMS workstation.
6. The following shall be displayed and alarmed as necessary at the existing Albireo Energy RUMC BMS:
   a. Space temperature and setpoint
   b. CFM and setpoint
   c. Supply damper command: 0-100%
   d. Pressure independent hot water control valve command: 0-100%
   e. Discharge temperature sensor

H. RCAV Boxes interlocked with CAV Boxes (Serving CATH lab and EP lab)
1. The BMS shall control and monitor each RCAV box via a BACnet IP DDC controller. Each RCAV controller shall be hardwired to the BMS network and shall communicate to the BMS system via BACnet IP communication.
2. Coordinate factory mounting and wiring of controller, actuator, and transformer with RCAV box manufacturer. Provide all controls not provided by Mfr for a complete installation.
   a. The RCAV box damper actuators serving the CATH lab and EP lab shall have fast speed actuators, it will not be acceptable to utilize the standard RCAV controller's integral actuator.
3. During occupied mode, the BMS shall control the return air damper to work in conjunction with the associated CAV box serving the respective lab. The BMS shall modulate the return air damper to maintain return air CFM setpoint.
   a. Return air CFM setpoint shall be calculated by measuring the associated CAV box CFM and subtracting the desired room CFM bias (adj) as shown on the mechanical schedule and confirmed by the TAB contractor.
4. During unoccupied mode, the RCAV box dampers shall be fully closed. If the space temperature falls below unoccupied setpoint, the associated AHU shall be enabled, and the RCAV box shall be controlled as described above with the associated CAV box until the space temperature is above the unoccupied setpoint for a period of (10) min (adj).
5. The following shall be displayed and alarmed as necessary at the existing Albireo Energy RUMC BMS: a. CFM and setpoint
   b. Return damper command: 0-100%

I. Room Pressure Monitors
1. The BMS shall provide room pressure monitors with a BACnet interface by the Room pressure monitor Mfr.
   a. Reference the mechanical drawings for quantities and locations of room pressure monitors.
2. The BMS shall be responsible for field wiring all items shipped loose with the room pressure monitor, including (but not limited to) mounting and wiring the room pressure monitor LCD display, wiring the room pressure transmitters, and wiring the door switches (all provided by the BMS contractor).

a. Note: For areas served by the room pressure monitors that have multiple doors, the BMS shall provide door switches for each door.

3. The BMS shall also wire a room temperature signal and room humidity signal from the BMS controller to the room pressure monitor LCD display, to allow the room pressure monitor LCD display to display room temperature and room humidity in addition to the room pressure.
4. The BMS shall bring BACnet communication to each room pressure monitor for remote monitoring.
5. The following shall be displayed and alarmed as necessary at the existing Albireo Energy RUMC BMS:
   a. All points available through the room pressure monitor BACnet interface (each Room pressure monitor)

J. Hot Water Radiant Ceiling Panel

1. The BMS shall provide field installed controls for the hot water radiant ceiling panels.
   a. Reference the mechanical drawings for quantities and locations.
2. During occupied Mode, if the space temperature falls below setpoint, the BMS shall modulate open the pressure independent hot water valve control valve. If the space temperature rises above setpoint the BMS shall modulate closed the pressure independent hot water control valve.
   a. If the hot wat radiant ceiling panel is located in an area served by a VAV box or CAV box, the associated VAV/CAV hot water coil shall act as the first stage of heating, and the hot water radiant ceiling panel shall act as the second stage of heating.
3. During unoccupied mode, the pressure independent hot water valve shall be closed. If the space temperature falls below unoccupied setpoint, the pressure independent hot water control valve shall be modulated open as described above until the space temperature is above the unoccupied setpoint for a period of (10) min (adj)
4. The following shall be displayed and alarmed as necessary at the existing Albireo Energy RUMC BMS:
   a. Space temperature and setpoint
   b. Pressure independent hot water control valve command: 0-100%

K. Split Air Cooled Air Conditioning System

1. The split AC unit shall be furnished with factory standalone DDC controls with a BACnet interface by the split AC unit Mfr.
2. The BMS contractor shall provide all required field wiring of controls that cannot be factory installed for proper AC unit operation, including but not limited to, mounting and wiring the AC unit Mfr remote control panel, interlock wiring between the AC unit and the respective outdoor condensing unit, and wiring the Mfr space temperature and humidity sensor.
3. The BMS shall bring BACnet communication to each AC unit for remote monitoring and control
4. The split AC unit shall be scheduled to operate 24/7 through a BMS timeclock schedule. Once enabled, the split AC unit shall start and operate to maintain space temperature and humidity through its own internal control system.
5. One spot leak detector (provided by the split AC unit Mfr) is to be installed in the corresponding condensate drain pan. The high level condensate and leak

detection device shall be wired to the AC unit controller, and shut down the unit upon a leak condition, and send an alarm to the BMS through the BACnet interface.

6. The following shall be displayed and alarmed as necessary at the existing Albireo Energy RUMC BMS:
   a. All points available through the Mfr BACnet interface

L. EF-1
   1. The exhaust fan shall start/stop through the BMS based on a time of day schedule.
      a. Once started, the BMS shall ramp up the ECM to the speed setpoint as determined during balancing.
   2. A current switch shall monitor the fan status and if the fan status doesn't match the command within 30 seconds (adj) following a start command, then a fan fail alarm shall be annunciated to the BMS.
   3. The automatic louvered damper located at the corresponding exhaust louver, if shown on the mechanical drawings, shall be hardwired interlocked by the BMS contractor to open and close with fan operation. The fan shall not be able to run until damper is fully open.
   4. The following shall be displayed and alarmed as necessary at the existing Albireo Energy RUMC BMS:
      a. Fan command: 0-100%, Start/stop, status (cs)

M. Existing Steam Reheat Coils
   1. The existing steam reheat coil controls shall remain as is and shall not be modified.
   2. The BMS contractor shall have no scope for the existing steam reheat coils on this project.

END OF SECTION

SECTION 232113
HYDRONIC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes pipe and fitting materials and joining methods for the following:

a. Copper tube and fittings.
b. Steel pipe and fittings.
c. Joining materials.
d. Transition fittings.
e. Dielectric fittings.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of the following:

a. Pipe.
b. Fittings.
c. Joining materials.

B. Delegated-Design Submittal:

a. Design calculations and detailed fabrication and assembly of pipe anchors and alignment guides, hangers and supports for multiple pipes, expansion joints and loops, and attachments of the same to the building structure.
b. Locations of pipe anchors and alignment guides and expansion joints and loops.
c. Locations of and details for penetrations, including sleeves and sleeve seals for exterior walls, floors, basement, and foundation walls.
d. Locations of and details for penetration and firestopping for fire- and smokerated wall and floor and ceiling assemblies.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Piping layout, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

a. Suspended ceiling components.
b. Other building services.
c. Structural members.

B. Qualification Data: For Installer.

C. Welding certificates.

D. Field quality-control reports.

E. Preconstruction Test Reports:

a. Water Analysis: Submit a copy of the water analysis to illustrate water quality available at Project site.

1.5 QUALITY ASSURANCE

A. Installer Qualifications:

a. Installers of Pressure-Sealed Joints: Installers shall be certified by pressureseal joint manufacturer as having been trained and qualified to join piping with pressure-seal pipe couplings and fittings.
b. Fiberglass Pipe and Fitting Installers: Installers of RTRF and RTRP shall be certified by manufacturer of pipes and fittings as having been trained and qualified to join fiberglass piping with manufacturer-recommended adhesive.

B. Steel Support Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

C. Pipe Welding: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code: Section IX.

a. Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation.
b. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

1.6 PRECONSTRUCTION TESTING

A. Preconstruction Testing Service: Engage a qualified testing agency to perform preconstruction testing on water quality.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature unless otherwise indicated:
   a. Hot-Water Heating Piping: 250 psig at 200 deg F.
   b. Chilled-Water Piping: 250 psig at 73 deg F.
   c. Makeup-Water Piping: 80 psig at] [150 psig] at 150 deg F.
   d. Condensate-Drain Piping: 150 deg F.
   e. Blowdown-Drain Piping: 200 deg F.
   f. Air-Vent Piping: 200 deg F.
   g. Safety-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

2.2 COPPER TUBE AND FITTINGS

A. Drawn-Temper Copper Tubing: ASTM B 88, Type L.

B. Annealed-Temper Copper Tubing: ASTM B 88, Type K.

C. DWV Copper Tubing: ASTM B 306, Type DWV.

D. Grooved, Mechanical-Joint, Wrought-Copper Fittings: ASME B16.22.

   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Anvil International, Inc.
      b. Star Pipe Products.
      c. Victaulic Company.

   b. Grooved-End Copper Fittings: ASTM B 75, copper tube or ASTM B 584, bronze casting.
   c. Grooved-End-Tube Couplings: Rigid pattern unless otherwise indicated; gasketed fitting. Ductile-iron housing with keys matching pipe and fitting grooves, prelubricated EPDM gasket rated for minimum 230 deg F for use with housing, and steel bolts and nuts.

E. Copper or Bronze Pressure-Seal Fittings:
   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following: a. NIBCO INC.
   b. Viega.

   b. Housing: Copper.
   c. O-Rings and Pipe Stops: EPDM.
   d. Tools: Manufacturer's special tools.
   e. Minimum 200-psig working-pressure rating at 250 deg F.

F. Copper, Mechanically Formed Tee Option: For forming T-branch on copper water tube.
   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. T-DRILL Industries Inc.

G. Wrought-Copper Unions: ASME B16.22.

2.3 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; welded and seamless, Grade B, and wall thickness as indicated in "Piping Applications" Article.

B. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125 and 250 as indicated in "Piping Applications" Article.

C. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300 as indicated in "Piping Applications" Article.

D. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in "Piping Applications" Article.

E. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 25, 125, and 250; raised ground face, and bolt holes spot faced as indicated in "Piping Applications" Article.

F. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.

G. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:

   a. Material Group: 1.1.
   b. End Connections: Butt welding.
   c. Facings: Raised face.

H. Grooved Mechanical-Joint Fittings and Couplings:
   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Anvil International, Inc.
      b. Central Sprinkler Company.
      c. Star Pipe Products.
      d. Victaulic Company.

   b. Joint Fittings: ASTM A 536, Grade 65-45-12 ductile iron; ASTM A 47/A 47M, Grade 32510 malleable iron; ASTM A 53/A 53M, Type F, E, or S, Grade B fabricated steel; or ASTM A 106/A 106M, Grade B steel fittings with grooves or shoulders constructed to accept grooved-end couplings; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.
   c. Couplings: Ductile- or malleable-iron housing and EPDM or nitrile gasket of central cavity pressure-responsive design; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.

I. Plain-End Mechanical-Joint Couplings:
   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Anvil International, Inc.
b. Central Sprinkler Company.
c. Star Pipe Products.
d. Victaulic Company.

b. Housing: ASTM A-536 Grade 65-45-12 segmented ductile iron or type 304 stainless steel.
c. Housing coating: None.
d. Gasket: EPDM or NBR.
e. Sealing Mechanism: Double-lip sealing system or carbon steel case-hardened jaws.
f. Bolts, hex nuts, washers, or lock bars based on manufacturer's design.
g. Minimum Pressure Rating: Equal to that of the joined pipes.

J. Steel Pressure-Seal Fittings:
a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Victaulic Company.

b. Housing: Steel.
c. O-Rings and Pipe Stop: EPDM.
d. Tools: Manufacturer's special tool.
e. Minimum 300-psig working-pressure rating at 230 deg F.

K. Steel Pipe Nipples: ASTM A 733, made of same materials and wall thicknesses as pipe in which they are installed.

2.4 JOINING MATERIALS

A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

a. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch maximum thickness unless otherwise indicated.

a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

C. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

D. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BAg-1, silver alloy for joining copper with bronze or steel.

E. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

F. Gasket Material: Thickness, material, and type suitable for fluid to be handled and working temperatures and pressures.

2.5 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.

B. Dielectric Unions:

a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. A.Y. McDonald Mfg. Co.
2. Capitol Manufacturing Company.
3. Central Plastics Company.
4. Hart Industries International, Inc.
5. Jomar International, Ltd.
6. Matco-Norca.
7. Watts Regulator Co.
8. Zurn Industries, LLC; AquaSpec Commercial Faucet Products.

b. Description:

a. Standard: ASSE 1079.
b. Pressure Rating: 250 psig minimum at 180 deg F.
c. End Connections: Solder-joint copper alloy and threaded ferrous.

C. Dielectric Flanges:

a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Capitol Manufacturing Company.
2. Central Plastics Company.
3. Matco-Norca.
4. Watts Regulator Co.
5. Zurn Industries, LLC; AquaSpec Commercial Faucet Products.

b. Description:

a. Standard: ASSE 1079.
b. Factory-fabricated, bolted, companion-flange assembly.
c. Pressure Rating: 175 psig minimum at 180 deg F.
d. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

D. Dielectric-Flange Insulating Kits:

a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Advance Products & Systems, Inc.
   2. Calpico, Inc.
   3. Central Plastics Company.
   4. Pipeline Seal and Insulator, Inc.

b. Description:

   a. Nonconducting materials for field assembly of companion flanges.
   b. Pressure Rating: 150 psig.
   c. Gasket: Neoprene or phenolic.
   d. Bolt Sleeves: Phenolic or polyethylene.
   e. Washers: Phenolic with steel backing washers.

E. Dielectric Nipples:

a. Manufacturers: Subject to compliance with requirements, provide products by one of the following: 1. Elster Perfection.
   2. Grinnell Mechanical Products.
   3. Matco-Norca.
   4. Precision Plumbing Products, Inc.
   5. Victaulic Company.

b. Description:

   a. Standard: IAPMO PS 66.
   b. Electroplated steel nipple, complying with ASTM F 1545.
   c. Pressure Rating: **300 psig at 225 deg F.**
   d. End Connections: Male threaded or grooved.
   e. Lining: Inert and noncorrosive, propylene.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. Hot-water heating piping, aboveground, NPS 2 and smaller, shall be any of the following:

   a. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered, brazed, pressure-seal joints.
   b. Schedule 40, Grade B steel pipe; Class 250, cast-iron fittings; cast-iron flanges and flange fittings; and threaded joints.

B. Hot-water heating piping, aboveground, NPS 2-1/2 and larger, shall be any of the following:

a. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered, brazed joints.
b. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forgedsteel flanges and flange fittings, and welded and flanged joints.

C. Hot-water heating piping installed belowground and within slabs shall be the following:
a. Type K, annealed-temper copper tubing, wrought-copper fittings, and soldered, brazed joints. Use the fewest possible joints.

D. Chilled-water piping, aboveground, NPS 2 and smaller, shall be any of the following:

a. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered, brazed, pressure-seal joints.
b. Schedule 40 steel pipe; Class 250, cast-iron fittings; cast-iron flanges and flange fittings; and threaded joints.

E. Chilled-water piping, aboveground, NPS 2-1/2 and larger, shall be any of the following:

a. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered, brazed joints.
b. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forgedsteel flanges and flange fittings, and welded and flanged joints.

F. Glycol cooling-water piping, aboveground, NPS 2 and smaller, shall be any of the following:

a. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered or brazed, pressure-seal joints.
b. Schedule 40 steel pipe; Class 250, cast-iron fittings; cast-iron flanges and flange fittings; and threaded joints.

G. Glycol cooling-water piping, aboveground, NPS 2-1/2 and larger, shall be any of the following:

a. Type L, drawn-temper copper tubing, wrought-copper fittings, and [soldered] [brazed] joints.
b. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forgedsteel flanges and flange fittings, and welded and flanged joints.
c. Schedule 40 steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.
d. Schedule 40 steel pipe, plain-end mechanical-coupled joints.

H. Glycol cooling-water piping installed belowground and within slabs shall be **either of** the following:

a. Type K, annealed-temper copper tubing, wrought-copper fittings, and soldered or brazed joints. Use the fewest possible joints.

I. Makeup-water piping installed aboveground shall be either of the following:

a. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered or brazed joints.

J. Makeup-Water Piping Installed Belowground and within Slabs: Type K, annealedtemper copper tubing, wrought-copper fittings, and soldered joints. Use the fewest possible joints.

K. Condensate-Drain Piping: Type M or Type DWV, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.

L. Condensate-Drain Piping: Schedule 40 PVC plastic pipe and fittings and solventwelded joints.

M. Blowdown-Drain Piping: Same materials and joining methods as for piping specified for the service in which blowdown drain is installed. N. Air-Vent Piping:

a. Inlet: Same as service where installed with metal-to-plastic transition fittings for plastic piping systems according to piping manufacturer's written instructions.
b. Outlet: Type K, annealed-temper copper tubing with soldered or flared joints.

O. Safety-Valve-Inlet and -Outlet Piping for Hot-Water Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed with metal-to-plastic transition fittings for plastic piping systems according to piping manufacturer's written instructions.

3.2 PIPING INSTALLATIONS

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

E. Install piping to permit valve servicing.

F. Install piping at indicated slopes.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. Install piping to allow application of insulation.

J. Select system components with pressure rating equal to or greater than system operating pressure.

K. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

L. Install drains, consisting of a tee fitting, NPS 3/4 ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

M. Install piping at a uniform grade of 0.2 percent upward in direction of flow.

N. Reduce pipe sizes using eccentric reducer fitting installed with level side up.

O. Install branch connections to mains using mechanically formed tee fittings in main pipe, with the branch connected to the bottom of the main pipe. For up-feed risers, connect the branch to the top of the main pipe. P. Install valves according to the following:

a. Section 230523.11 "Globe Valves for HVAC Piping."
b. Section 230523.12 "Ball Valves for HVAC Piping."
c. Section 230523.13 "Butterfly Valves for HVAC Piping."
d. Section 230523.14 "Check Valves for HVAC Piping."
e. Section 230523.15 "Gate Valves for HVAC Piping."

Q. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

R. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.

S. Install shutoff valve immediately upstream of each dielectric fitting.

T. Comply with requirements in Section 230516 "Expansion Fittings and Loops for HVAC Piping" for installation of expansion loops, expansion joints, anchors, and pipe alignment guides.

U. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for identifying piping.

V. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

W. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

X. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

3.3 DIELECTRIC FITTING INSTALLATION

A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.

B. Dielectric Fittings for NPS 2 and Smaller: Use dielectric nipples or unions.

C. Dielectric Fittings for NPS 2-1/2 to NPS 4: Use dielectric flanges, flange kits, nipples.

D. Dielectric Fittings for NPS 5 and Larger: Use dielectric flange kits.

3.4 HANGERS AND SUPPORTS

A. Comply with requirements in Section 230529 "Hangers and Supports for HVAC Piping and Equipment" for hanger, support, and anchor devices. Comply with the following requirements for maximum spacing of supports.

B. Comply with requirements in Section 230548 "Vibration and Seismic Controls for HVAC" for seismic restraints.

C. Install the following pipe attachments:

a. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet long.
b. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet or longer.
c. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
d. Spring hangers to support vertical runs.
e. Provide copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.
f. On plastic pipe, install pads or cushions on bearing surfaces to prevent hanger from scratching pipe.

D. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:

a. NPS 3/4: Maximum span, 7 feet.

b. NPS 1: Maximum span, 7 feet.
c. NPS 1-1/2: Maximum span, 9 feet.
d. NPS 2: Maximum span, 10 feet.
e. NPS 2-1/2: Maximum span, 11 feet.
f. NPS 3 and Larger: Maximum span, 12 feet.

E. Install hangers for drawn-temper copper piping with the following maximum spacing and minimum rod sizes:

a. NPS 3/4: Maximum span, 5 feet, minimum rod size, 1/4 inch.
b. NPS 1: Maximum span, 6 feet; minimum rod size, 1/4 inch.
c. NPS 1-1/4: Maximum span, 7 feet; minimum rod size, 3/8 inch.
d. NPS 1-1/2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
e. NPS 2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
f. NPS 2-1/2: Maximum span, 9 feet; minimum rod size, 3/8 inch.
g. NPS 3 and Larger: Maximum span, 10 feet; minimum rod size, 3/8 inch.

F. Support vertical runs at roof, at each floor, and at 10-foot intervals between floors.

3.5 PIPE JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.

D. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8/A5.8M.

E. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

a. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
b. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

F. Welded Joints: Construct joints according to AWS D10.12M/D10.12, using qualified processes and welding operators according to "Quality Assurance" Article.

G. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

H. Grooved Joints: Assemble joints with coupling and gasket, lubricant, and bolts. Cut or roll grooves in ends of pipe based on pipe and coupling manufacturer's written instructions for pipe wall thickness. Use grooved-end fittings and rigid, groovedend-pipe couplings.

I. Plain-End Mechanical-Coupled Joints: Prepare, assemble, and test joints in accordance with manufacturer's written installation instructions.

J. Mechanically Formed, Copper-Tube-Outlet Joints: Use manufacturer-recommended tool and procedure, and brazed joints.

K. Pressure-Sealed Joints: Use manufacturer-recommended tool and procedure. Leave insertion marks on pipe after assembly.

3.6 TERMINAL EQUIPMENT CONNECTIONS

A. Sizes for supply and return piping connections shall be the same as or larger than equipment connections.

B. Install control valves in accessible locations close to connected equipment.

C. Install bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.

D. Install ports for pressure gages and thermometers at coil inlet and outlet connections. Comply with requirements in Section 230519 "Meters and Gages for HVAC Piping."

3.7 FIELD QUALITY CONTROL

A. Prepare hydronic piping according to ASME B31.9 and as follows:

a. Leave joints, including welds, uninsulated and exposed for examination during test.
b. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
c. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.
d. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
e. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.

B. Perform the following tests on hydronic piping:

a. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
b. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
c. Isolate expansion tanks and determine that hydronic system is full of water.
d. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7

times the "SE" value in Appendix A in ASME B31.9, "Building Services Piping."
e. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
f. Prepare written report of testing.

C. Perform the following before operating the system:

a. Open manual valves fully.
b. Inspect pumps for proper rotation.
c. Set makeup pressure-reducing valves for required system pressure.
d. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
e. Set temperature controls so all coils are calling for full flow.
f. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, cooling towers, to specified values.
g. Verify lubrication of motors and bearings.

END OF SECTION

SECTION 232116
HYDRONIC PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Hydronic specialty valves.
2. Air-control devices.
3. Strainers.
4. Connectors.

B. Related Requirements:

1. Section 230516 "Expansion Fittings and Loops for HVAC Piping" for expansion fittings and loops.
2. Section 230523.11 "Globe Valves for HVAC Piping" for specification and installation requirements for globe valves common to most piping systems.
3. Section 230523.12 "Ball Valves for HVAC Piping" for specification and installation requirements for ball valves common to most piping systems.
4. Section 230523.13 "Butterfly Valves for HVAC Piping" for specification and installation requirements for butterfly valves common to most piping systems.
5. Section 230523.14 "Check Valves for HVAC Piping" for specification and installation requirements for check valves common to most piping systems.
6. Section 230523.15 "Gate Valves for HVAC Piping" for specification and installation requirements for gate valves common to most piping systems.
7. Section 230923.11 "Control Valves" for automatic control valve and sensor specifications, installation requirements, and locations.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product:

1. Include construction details and material descriptions for hydronic piping specialties.
2. Include rated capacities, operating characteristics, and furnished specialties and accessories.

3. Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For hydronic piping specialties to include in emergency, operation, and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Differential Pressure Meter: For each type of balancing valve and automatic flow control valve, include flowmeter, probes, hoses, flow charts, and carrying case.

1.6 QUALITY ASSURANCE

A. Pipe Welding: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code: Section IX.

B. Safety Valves and Pressure Vessels: Shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

PART 2 - PRODUCTS

2.1 HYDRONIC SPECIALTY VALVES

A. Bronze, Calibrated-Orifice, Balancing Valves:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

   a. Armstrong Pumps, Inc.
   b. Bell & Gossett Domestic Pump.
   c. Flow Design Inc.
   d. Gerand Engineering Co.
   e. Griswold Controls.
   f. Macon
   g. Nexus Valve, Inc.
   h. Taco.
   i. Tour & Andersson; available through Victaulic Company.

2. Body: Bronze, ball or plug type with calibrated orifice or venturi.
3. Ball: Brass or stainless steel.
4. Plug: Resin.
5. Seat: PTFE.
6. End Connections: Threaded or socket.
7. Pressure Gage Connections: Integral seals for portable differential pressure meter.
8. Handle Style: Lever, with memory stop to retain set position.
9. CWP Rating: Minimum 125 psig.
10. Maximum Operating Temperature: 250 deg F.

B. Cast-Iron or Steel, Calibrated-Orifice, Balancing Valves:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

   a. Armstrong Pumps, Inc.
   b. Bell & Gossett Domestic Pump.
   c. Flow Design Inc.
   d. Gerand Engineering Co.
   e. Griswold Controls.
   f. Macon
   g. Nexus Valve, Inc.
   h. Taco.
   i. Tour & Andersson.

2.
3. Body: Cast-iron or steel body, ball, plug, or globe pattern with calibrated orifice or venturi.
4. Ball: Brass or stainless steel.
5. Stem Seals: EPDM O-rings.
6. Disc: Glass and carbon-filled PTFE.
7. Seat: PTFE.
8. End Connections: Flanged or grooved.
9. Pressure Gage Connections: Integral seals for portable differential pressure meter.
10. Handle Style: Lever, with memory stop to retain set position.
11. CWP Rating: Minimum 125 psig.
12. Maximum Operating Temperature: 250 deg F.

C. Diaphragm-Operated, Pressure-Reducing Valves: ASME labeled.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. AMTROL, Inc.
b. Armstrong Pumps, Inc.
c. Bell & Gossett Domestic Pump.
d. Conbraco Industries, Inc.
e. Spence Engineering Company, Inc.
f. Watts Regulator Co.

2. Body: Bronze or brass.
3. Disc: Glass and carbon-filled PTFE.
4. Seat: Brass.
5. Stem Seals: EPDM O-rings.
6. Diaphragm: EPT.
7. Low inlet-pressure check valve.
8. Inlet Strainer: 304 or 316 stainless steel, removable without system shutdown.
9. Valve Seat and Stem: Noncorrosive.
10. Valve Size, Capacity, and Operating Pressure: Selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

D. Diaphragm-Operated Safety Valves: ASME labeled.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. AMTROL, Inc.
b. Armstrong Pumps, Inc.
c. Bell & Gossett Domestic Pump.
d. Conbraco Industries, Inc.
e. Spence Engineering Company, Inc.
f. Watts Regulator Co.

2. Body: Bronze or brass.
3. Disc: Glass and carbon-filled PTFE.
4. Seat: Brass.
5. Stem Seals: EPDM O-rings.
6. Diaphragm: EPT.
7. Wetted, Internal Work Parts: Brass and rubber.
8. Inlet Strainer: 304 or 316 stainless steel, removable without system shutdown.
9. Valve Seat and Stem: Noncorrosive.
10. Valve Size, Capacity, and Operating Pressure: Comply with ASME Boiler and Pressure Vessel Code: Section IV, and selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

E. Automatic Flow-Control Valves:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. Flow Design Inc.
   b. Griswold Controls.
   c. Hays Fluid Controls
   d. Macon
   e. Nexus Valve, Inc.
2. Body: Brass or ferrous metal.
3. Flow Control Assembly, provide either of the following:
   a. Piston and Spring Assembly: Stainless steel, Corrosion resistant, tamper proof, self-cleaning, and removable.
   b. Elastomeric Diaphragm and Polyphenylsulfone Orifice Plate: Operating ranges within 2- to 80-psig differential pressure.
4. Combination Assemblies: Include bronze or brass-alloy ball valve.
5. Identification Tag: Marked with zone identification, valve number, and flow rate.
6. Size: Same as pipe in which installed.
7. Performance: Maintain constant flow within plus or minus 10 percent, regardless of system pressure fluctuations.
8. Minimum CWP Rating: 175 psig.
9. Maximum Operating Temperature: 200 deg F.

2.2 AIR-CONTROL DEVICES

A. Manual Air Vents:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. AMTROL, Inc.
   b. Armstrong Pumps, Inc.
   c. Bell & Gossett Domestic Pump.
   d. Nexus Valve, Inc.
   e. Taco, Inc.
2. Body: Bronze.
3. Internal Parts: Nonferrous.
4. Operator: Screwdriver or thumbscrew.
5. Inlet Connection: NPS 1/2.
6. Discharge Connection: NPS 1/8.
7. CWP Rating: 150 psig.
8. Maximum Operating Temperature: 225 deg F. B. Automatic Air Vents:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

   a. AMTROL, Inc.

   b. Armstrong Pumps, Inc.

   c. Bell & Gossett Domestic Pump.

   d. Nexus Valve, Inc.

   e. Taco, Inc.
2. Body: Bronze or cast iron.
3. Internal Parts: Nonferrous.
4. Operator: Noncorrosive metal float.
5. Inlet Connection: NPS 1/2.
6. Discharge Connection: NPS ¼..
7. CWP Rating: 150 psig.
8. Maximum Operating Temperature: 240 deg F.

C. Air-Charge Fittings: Schrader valve, stainless steel with EPDM seats.

2.3 STRAINERS

A. Y-Pattern Strainers:

1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: Stainless-steel, **20**-mesh strainer, or perforated stainlesssteel basket.
4. CWP Rating: 125 psig. B. Basket Strainers:

1. Body: ASTM A 126, Class B, high-tensile cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: **40**-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 125 psig. C. T-Pattern Strainers:

1. Body: Ductile or malleable iron with removable access coupling and end cap for strainer maintenance.
2. End Connections: Grooved ends.
3. Strainer Screen: **40**-mesh startup strainer, and perforated stainless-steel basket with 57 percent free area.
4. CWP Rating: 750 psig.

2.4 CONNECTORS

A. Stainless-Steel Bellow, Flexible Connectors:

1. Body: Stainless-steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket.
2. End Connections: Threaded or flanged to match equipment connected.
3. Performance: Capable of 3/4-inch misalignment.
4. CWP Rating: 150 psig.
5. Maximum Operating Temperature: 250 deg F. B. Spherical, Rubber, Flexible

Connectors:

1. Body: Fiber-reinforced rubber body.
2. End Connections: Steel flanges drilled to align with Classes 150 and 300 steel flanges.
3. Performance: Capable of misalignment.
4. CWP Rating: 150 psig.
5. Maximum Operating Temperature: 250 deg F).

PART 3 - EXECUTION

3.1 VALVE APPLICATIONS

A. Install shutoff-duty valves at each branch connection to supply mains and at supply connection to each piece of equipment.

B. Install throttling-duty or calibrated-orifice, balancing valves at each branch connection to return main.

C. Install calibrated-orifice, balancing valves in the return pipe of each heating or cooling terminal.

D. Install check valves at each pump discharge and elsewhere as required to control flow direction.

E. Install safety valves at hot-water generators and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install drip-pan elbow on safety-valve outlet and pipe without valves to the outdoors; pipe drain to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, for installation requirements.

F. Install pressure-reducing valves at makeup-water connection to regulate system fill pressure.

3.2 HYDRONIC SPECIALTIES INSTALLATION

A. Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.

B. Install automatic air vents at high points of system piping in mechanical equipment rooms only. Install manual vents at heat-transfer coils and elsewhere as required for air venting.

END OF SECTION

SECTION 232213
STEAM AND CONDENSATE HEATING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes pipe and fittings for LP steam and condensate piping:

1. Steel pipe and fittings.
2. Joining materials. B. Related Requirements:

1. Section 232216 "Steam and Condensate Heating Piping Specialties" for strainers, flash tanks, special-duty valves, steam traps, thermostatic air vents and vacuum breakers, and steam and condensate meters.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of the following:

1. Steel pipe and fitting.
2. Joining material.

B. Delegated-Design Submittal:

1. Design calculations and detailed fabrication and assembly of pipe anchors and alignment guides, hangers and supports for multiple pipes, expansion joints and loops, and attachments of the same to the building structure.
2. Locations of pipe anchors and alignment guides and expansion joints and loops.
3. Locations of and details for penetrations, including sleeves and sleeve seals for exterior walls, floors, basement, and foundation walls.
4. Locations of and details for penetration and firestopping for fire- and smokerated wall and floor and ceiling assemblies.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Piping layout, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Suspended ceiling components.

2. Other building services.
3. Structural members.

B. Qualification Data: For Installer.

C. Welding certificates.

D. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Steel Support Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Pipe Welding: Qualify procedures and operators according to the following:

1. ASME Compliance: Comply with ASME B31.1, "Power Piping, “and ASME B31.9, "Building Services Piping," for materials, products, and installation.
2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

C. Welding Requirements
1. All piping over two (2) inches in diameter shall be butt-welded. Piping 2 inches and under in diameter may be socket welded.
2. Radiographic (X-ray) examination, when required, shall be performed on butt welds in accordance with 2014 NYCMC 1203.3.6: All joints shall be welded with a welding procedure developed and qualified in accordance with the ASME Boiler and Pressure Vessel Code , Section IX (Welding and Brazing Qualifications) or in accordance with AWS B2.1 Specifications for Welding Procedure and Performance Qualification.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working pressures and temperatures unless otherwise indicated:
1. LP Steam Piping: 15 psig.
2. Condensate Piping: 150 psig at 250 deg F.

2.2 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel, plain ends, welded and seamless, Grade B, and Schedule as indicated in piping applications articles.

B. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125, 150, and 300 as indicated in piping applications articles.

C. Malleable-Iron Threaded Fittings: ASME B16.3; Classes 150 and 300 as indicated in piping applications articles.

D. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in piping applications articles.

E. Cast-Iron Threaded Flanges and Flanged Fittings: ASME B16.1, Classes 125 and 250 as indicated in piping applications articles; raised ground face, and bolt holes spot faced.

F. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.

G. Wrought-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:

1. Material Group: 1.1.
2. End Connections: Butt welding.
3. Facings: Raised face.

H. Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M, black steel of same Type, Grade, and Schedule as pipe in which installed.

2.3 DIELECTRIC FITTINGS

A. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.

B. Insulating Material: Suitable for system fluid, pressure, and temperature.

C. Dielectric Unions:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Capitol Manufacturing Company.
   b. Central Plastics Company.
   c. Hart Industries, International Inc.
   d. Watts Water Technologies, Inc.
   e. Zurn Plumbing Products Group.

2. Factory-fabricated union assembly, for 250-psig minimum working pressure at 180 deg F.

D. Dielectric Flanges:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Capitol Manufacturing Company.
   b. Central Plastics Company.
   c. Watts Water Technologies, Inc.

2. Factory-fabricated companion-flange assembly, for 150- or 300-psig minimum working pressure as required to suit system pressures.

E. Dielectric-Flange Kits:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Advance Products & Systems, Inc.
    b. Calpico, Inc.
    c. Central Plastics Company.
    d. Pipeline Seal and Insulator, Inc.

2. Companion-flange assembly for field assembly. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.

2.4 Separate companion flanges and steel bolts and nuts shall have 150- or 300psig minimum working pressure as required to suit system pressures.

2.5 JOINING MATERIALS

A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch maximum thickness unless otherwise indicated.

    a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
    b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

C. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

D. Welding Materials: Comply with Section II, Part C, of ASME Boiler and Pressure Vessel Code for welding materials appropriate for wall thickness and for chemical analysis of pipe being welded.

PART 3 - EXECUTION

3.1 LP STEAM PIPING APPLICATIONS

A. LP Steam Piping, NPS 2 and Smaller: Schedule 40, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.

B. LP Steam Piping, NPS 2-1/2 through NPS 12: Schedule 40, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.

C. LP Steam Piping, NPS 14 through NPS 18: Schedule 30, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.

D. LP Steam Piping, NPS 20 and Larger: Schedule 20, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.

E. Condensate piping above grade, NPS 2 and smaller, shall be the following:

1. Schedule 80, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.

F. Condensate piping above grade, NPS 2-1/2 and larger, shall be the following:

1. Schedule 80, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.

G. Condensate piping below grade, NPS 2 and smaller, shall be the following:

1. Schedule 80, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.

H. Condensate piping below grade, NPS 2-1/2 and larger, shall be the following:

1. Schedule 80, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.

3.2 VALVE APPLICATIONS

A. Install shutoff duty valves at branch connections to steam supply mains, at steam supply connections to equipment, and at the outlet of steam traps.

B. Install safety valves on pressure-reducing stations and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install safety-valve discharge piping, without valves, to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, for installation requirements.

3.3 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless otherwise indicated.

D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

E. Install piping to permit valve servicing.

F. Install piping free of sags and bends.

G. Install fittings for changes in direction and branch connections.

H. Install piping to allow application of insulation.

I. Select system components with pressure rating equal to or greater than system operating pressure.

J. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

K. Install drains, consisting of a tee fitting, NPS 3/4 full port-ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

L. Install steam supply piping at a minimum uniform grade of 0.2 percent downward in direction of steam flow.

M. Install condensate return piping at a minimum uniform grade of 0.4 percent downward in direction of condensate flow.

N. Reduce pipe sizes using eccentric reducer fitting installed with level side down.

O. Install branch connections to mains using mechanically formed tee fittings in main pipe, with the branch connected to top of main pipe.

P. Install valves according to the following Sections or other Sections as needed:

1. Section 230523.11 "General Duty Valves for HVAC Piping."

Q. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

R. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.

S. Install shutoff valve immediately upstream of each dielectric fitting.

T. Install strainers on supply side of control valves, pressure-reducing valves, traps, and elsewhere as indicated. Install NPS 3/4 nipple and full port ball valve in blowdown connection of strainers NPS 2 and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2.

U. Comply with requirements in Section 230516 "Expansion Fittings and Loops for HVAC Piping" for installation of expansion loops, expansion joints, anchors, and pipe alignment guides.

V. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for identifying piping.

W. Install drip legs at low points and natural drainage points such as ends of mains, bottoms of risers, and ahead of pressure regulators, and control valves.

1. On straight runs with no natural drainage points, install drip legs at intervals not exceeding 300 feet.
2. Size drip legs same size as main. In steam mains NPS 6 and larger, drip leg size can be reduced, but to no less than NPS 4.

X. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

Y. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

Z. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

3.4 STEAM AND CONDENSATE PIPING SPECIALTIES INSTALLATION

A. Comply with requirements in Section 232216 "Steam and Condensate Heating Piping Specialties" for installation requirements for strainers, flash tanks, specialduty valves, steam traps, thermostatic air vents and vacuum breakers, and steam and condensate meters.

3.5 HANGERS AND SUPPORTS

A. Comply with requirements in Section 230529 "Hangers and Supports for HVAC Piping and Equipment" for installation of hangers and supports. Comply with requirements below for maximum spacing.

B. Comply with requirements in Section 230548 "Vibration and Seismic Controls for HVAC" for seismic restraints.

C. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet long.

2. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.

D. Install hangers for steel steam supply piping with the following maximum spacing:

1. NPS 3/4: Maximum span, 9 feet.
2. NPS 1: Maximum span, 9 feet.
3. NPS 1-1/2: Maximum span, 12 feet.
4. NPS 2: Maximum span, 13 feet.
5. NPS 2-1/2: Maximum span, 14 feet.
6. NPS 3 and Larger: Maximum span, 15 feet

E. Install hangers for steel steam condensate piping with the following maximum spacing:

1. NPS 3/4: Maximum span, 7 feet.
2. NPS 1: Maximum span, 7 feet.
3. NPS 1-1/2: Maximum span, 9 feet.
4. NPS 2: Maximum span, 10 feet.
5. NPS 2-1/2: Maximum span, 11 feet.
6. NPS 3 and Larger: Maximum span, 12 feet.

F. Support vertical runs at roof, at each floor, and at 10-foot intervals between floors.

3.6 PIPE JOINT CONSTRUCTION

A. Ream ends of pipes and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

D. Welded Joints: Construct joints according to AWS D10.12M/D10.12, using qualified processes and welding operators according to "Quality Assurance" Article.

E. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.7 TERMINAL EQUIPMENT CONNECTIONS

A. Size for supply and return piping connections shall be the same as or larger than equipment connections.

B. Install traps and control valves in accessible locations close to connected equipment.

C. Install bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.

D. Install vacuum breakers downstream from control valve, close to coil inlet connection.

E. Install a drip leg at coil outlet.

3.8 FIELD QUALITY CONTROL

A. Prepare steam and condensate piping according to ASME B31.1, "Power Piping," and ASME B31.9, "Building Services Piping," and as follows:

1. Leave joints, including welds, uninsulated and exposed for examination during test.
2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
3. Flush system with clean water. Clean strainers.
4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

D. Perform the following tests and inspections with the assistance of a factoryauthorized service representative:

1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
2. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify

that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength.

3. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.

E. Prepare test and inspection reports. END OF SECTION

SECTION 232216
STEAM AND CONDENSATE HEATING PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes the following piping specialties for steam and condensate piping:

1. Strainers.
2. Stop-check valves.
3. Steam traps.
4. Thermostatic air vents and vacuum breakers.
5. Flexible connectors. B. Related Requirements:

1. Section 230516 "Expansion Fittings and Loops for HVAC Piping" for expansion fittings and loops.
2. Section 230523.11 "General Duty Valves for HVAC Piping" for specification and installation requirements for globe valves common to most piping systems.
3. Section 230923.11. "Control Valves" for automatic control valve and sensor specifications, installation requirements, and locations.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Strainer.
2. Valve.
3. Steam trap.
4. Air vent and vacuum breaker.
5. Connector.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For valves, safety valves, pressure-reducing valves, steam traps, air vents, vacuum breakers, and meters to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Pipe Welding: Qualify procedures and operators according to the following:

1. ASME Compliance: Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp flash tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working pressures and temperatures unless otherwise indicated:
1. LP Steam Piping: 15 psig and less.
2. Condensate Piping: 150 psig at 250 deg F.
3. Air-Vent and Vacuum-Breaker Piping: Equal to pressure of the piping system to which it is attached.

2.2 STRAINERS

A. Y-Pattern Strainers:

1. Body: ASTM A 126, Class B cast iron, with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for strainers NPS 2 and smaller; flanged ends for strainers NPS 2-1/2 and larger.
3. Strainer Screen: Stainless-steel, 20 or 40-mesh strainer or perforated stainless-steel basket.
4. Tapped blow off plug.
5. CWP Rating: 250-psig working steam pressure. B. Basket Strainers:

1. Body: ASTM A 126, Class B cast iron, with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for strainers NPS 2 and smaller; flanged ends for strainers NPS 2-1/2 and larger.
3. Strainer Screen: Stainless-steel, 20-mesh strainer and perforated stainlesssteel basket with 50 percent free area.
4. CWP Rating: 250-psig working steam pressure.

2.3 STOP-CHECK VALVES

A. Stop-Check Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by the following:
   a. A.Y. McDonald Mfg. Co.
   b. Cincinnati Valve Company.

c. Crane; Crane Energy Flow Solutions.
d. Jenkins Valves.

2. Body and Bonnet: Malleable iron.
3. End Connections: Flanged.
4. Disc: Cylindrical with removable liner and machined seat.
5. Stem: Brass alloy.
6. Operator: Outside screw and yoke with cast-iron handwheel.
7. Packing: PTFE-impregnated packing with two-piece packing gland assembly.
8. Pressure Class: 250.

2.4 STEAM TRAPS

A. Thermostatic Steam Traps:
1. Manufacturers: Subject to compliance with requirements, provide products by the following:
    a. Armstrong International, Inc.
    b. Barnes & Jones, Inc.
    c. Dunham-Bush, Inc.
    d. Hoffman Specialty.
    e. Spirax Sarco, Inc.
    f. Watson McDaniel.

2. Body: Bronze angle-pattern body with integral union tailpiece and screw-in cap.
3. Trap Type: Balanced pressure.
4. Bellows: Stainless steel or monel.
5. Head and Seat: Replaceable, hardened stainless steel.
6. Pressure Class: 125.

B. Thermodynamic Steam Traps:
1. Manufacturers: Subject to compliance with requirements, provide products by the following:
    a. Armstrong International, Inc.
    b. Barnes & Jones, Inc.
    c. Dunham-Bush, Inc.
    d. Hoffman Specialty.
    e. Spirax Sarco, Inc.
    f. Watson McDaniel.

2. Body: Stainless steel with screw-in cap.
3. End Connections: Threaded.
4. Disc and Seat: Stainless steel.
5. Maximum Operating Pressure: 600 psig. C. Float and

Thermostatic Steam Traps:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
   a. Armstrong International, Inc.
   b. Barnes & Jones, Inc.
   c. Dunham-Bush, Inc.
   d. Hoffman Specialty.
   e. Spirax Sarco, Inc.
   f. Watson McDaniel.

2. Body and Bolted Cap: ASTM A 126 cast iron.
3. End Connections: Threaded.
4. Float Mechanism: Replaceable, stainless steel.
5. Head and Seat: Hardened stainless steel.
6. Trap Type: Balanced pressure.
7. Thermostatic Bellows: Stainless steel or monel.
8. Thermostatic air vent capable of withstanding 45 deg F of superheat and resisting water hammer without sustaining damage.
9. Vacuum Breaker: Thermostatic with phosphor bronze bellows, and stainlesssteel cage, valve, and seat.
10. Maximum Operating Pressure: 125 psig.

2.5 THERMOSTATIC AIR VENTS AND VACUUM BREAKERS

A. Thermostatic Air Vents:
1. Manufacturers: Subject to compliance with requirements, provide products by the following:
   a. Armstrong International, Inc.
   b. Barnes & Jones, Inc.
   c. Dunham-Bush, Inc.
   d. Hoffman Specialty.
   e. Spirax Sarco, Inc.
   f. Watson McDaniel.

2. Body: Cast iron, bronze, or stainless steel.
3. End Connections: Threaded.
4. Float, Valve, and Seat: Stainless steel.
5. Thermostatic Element: Phosphor bronze bellows in a stainless-steel cage.
6. Pressure Rating: 125 psig or 300 psig.
7. Maximum Temperature Rating: 350 deg F.

B. Vacuum Breakers:
1. Manufacturers: Subject to compliance with requirements, provide products by the following:
   a. Armstrong International, Inc.
   b. Dunham-Bush, Inc.
   c. Hoffman Specialty.
   d. Johnson Corporation (The)

e. Spirax Sarco, Inc.

2. Body: Cast iron, bronze, or stainless steel.
3. End Connections: Threaded.
4. Sealing Ball, Retainer, Spring, and Screen: Stainless steel.
5. O-Ring Seal: Ethylene propylene rubber.
6. Pressure Rating: 125 psig or 300 psig.
7. Maximum Temperature Rating: 350 deg F.

2.6 FLEXIBLE CONNECTORS

A. Stainless-Steel Bellows, Flexible Connectors:
1. Manufacturers: Subject to compliance with requirements, provide products by the following:
   a. Duraflex, Inc.
   b. Flexicraft Industries.
   c. Hyspan Precision Products, Inc.
   d. Mason Industries, Inc.
   e. Metraflex Company (The).
   f. Twin City Hose, Inc

2. Body: Stainless-steel bellows with woven, flexible, bronze, wire-reinforced, protective jacket.
3. End Connections: Threaded or flanged to match equipment connected.
4. Performance: Capable of 3/4-inch misalignment.
5. CWP Rating: 150 psig.
6. Maximum Operating Temperature: 250 deg F.

PART 3 - EXECUTION

3.1 VALVE APPLICATIONS

A. Install shutoff duty valves at branch connections to steam supply mains, at steam supply connections to equipment, and at the outlet of steam traps.

B. Install safety valves on pressure-reducing stations and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install safety-valve discharge piping, without valves, to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, for installation requirements.

3.2 PIPING INSTALLATION

A. Install piping to permit valve servicing.

B. Install drains, consisting of a tee fitting, NPS 3/4 full-port ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

C. Install valves according to Section 230523.11 "Globe Valves for HVAC Piping," Section 230523.12 "Ball Valves for HVAC Piping," Section 230523.13 "Butterfly Valves for HVAC Piping," Section 230523.14 "Check Valves for HVAC Piping," and Section 230523.15 "Gate Valves for HVAC Piping."

D. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment and elsewhere as indicated.

E. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.

F. Install shutoff valve immediately upstream of each dielectric fitting.

G. Install strainers on supply side of control valves, pressure-reducing valves, traps, and elsewhere as indicated. Install NPS 3/4 nipple and full-port ball valve in blowdown connection of strainers NPS 2 and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2.

3.3 STEAM-TRAP INSTALLATION

A. Install steam traps in accessible locations as close as possible to connected equipment.

B. Install full-port ball valve, strainer, and union upstream from trap; install union, check valve, and full-port ball valve downstream from trap unless otherwise indicated.

3.4 TERMINAL EQUIPMENT CONNECTIONS

A. Install traps and control valves in accessible locations close to connected equipment.

B. Install bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.

C. Install vacuum breakers downstream from control valve, close to coil inlet connection.

END OF SECTION

SECTION 232300
REFRIGERANT PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Refrigerant pipes and fittings.
2. Refrigerant piping valves and specialties.
3. Refrigerants.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of valve, refrigerant piping, and piping specialty.

1. Include pressure drop, based on manufacturer's test data, for the following:

   a. Thermostatic expansion valves.
   b. Solenoid valves.
   c. Hot-gas bypass valves.
   d. Filter dryers.
   e. Strainers.
   f. Pressure-regulating valves. B. Shop Drawings:

1. Show layout of refrigerant piping and specialties, including pipe, tube, and fitting sizes; flow capacities; valve arrangements and locations; slopes of horizontal runs; oil traps; double risers; wall and floor penetrations; and equipment connection details.
2. Show piping size and piping layout, including oil traps, double risers, specialties, and pipe and tube sizes to accommodate, as a minimum, equipment provided, elevation difference between compressor and evaporator, and length of piping to ensure proper operation and compliance with warranties of connected equipment.
3. Show interface and spatial relationships between piping and equipment.

4. Shop Drawing Scale: 1/4 inch equals 1 foot.

1.4 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For refrigerant valves and piping specialties to include in maintenance manuals.

1.6 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to 2010 ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

B. Comply with ASHRAE 15, "Safety Code for Refrigeration Systems."

C. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

1.7 COORDINATION

A. Coordinate size and location of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07, Roof Accessories.

1.8 PRODUCT STORAGE AND HANDLING

A. Store piping with end caps in place to ensure that piping interior and exterior are clean when installed.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Line Test Pressure for Refrigerant R-134a:

1. Suction Lines for Air-Conditioning Applications: 115 psig.
2. Suction Lines for Heat-Pump Applications: 225 psig.

3. Hot-Gas and Liquid Lines: 225 psig.

B. Line Test Pressure for Refrigerant R-407C:

1. Suction Lines for Air-Conditioning Applications: 230 psig.
2. Suction Lines for Heat-Pump Applications: 380 psig.
3. Hot-Gas and Liquid Lines: 380 psig.

C. Line Test Pressure for Refrigerant R-410A:

1. Suction Lines for Air-Conditioning Applications: 300 psig.
2. Suction Lines for Heat-Pump Applications: 535 psig.
3. Hot-Gas and Liquid Lines: 535 psig.

2.2 COPPER TUBE AND FITTINGS

A. Copper Tube: ASTM B 88, Type K or L, ASTM B 280, Type ACR.

B. Wrought-Copper Fittings: ASME B16.22.

C. Wrought-Copper Unions: ASME B16.22.

D. Solder Filler Metals: ASTM B 32. Use 95-5 tin antimony or alloy HB solder to join copper socket fittings on copper pipe.

E. Brazing Filler Metals: AWS A5.8/A5.8M.

F. Flexible Connectors:

1. Body: Tin-bronze bellows with woven, flexible, tinned-bronze-wire-reinforced protective jacket.
2. End Connections: Socket ends.
3. Offset Performance: Capable of minimum 3/4-inch misalignment in minimum 7-inch- long assembly.
4. Working Pressure Rating: Factory test at minimum 500 psig.
5. Maximum Operating Temperature: 250 deg F.

2.3 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; type, grade, and wall thickness as selected in piping application articles.

B. Wrought-Steel Fittings: ASTM A 234/A 234M, for welded joints.

C. Steel Flanges and Flanged Fittings: ASME B16.5, steel, including bolts, nuts, and gaskets, bevel-welded end connection, and raised face.

D. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded. E. Flanged Unions:

1. Body: Forged-steel flanges for NPS 1 to NPS 1-1/2 and ductile iron for NPS 2 to NPS 3. Apply rust-resistant finish at factory.
2. Gasket: Fiber asbestos free.
3. Fasteners: Four plated-steel bolts, with silicon bronze nuts. Apply rustresistant finish at factory.
4. End Connections: Brass tailpiece adapters for solder-end connections to copper tubing.
5. Offset Performance: Capable of minimum 3/4-inch misalignment in minimum 7-inch- long assembly.
6. Pressure Rating: Factory test at minimum 400 psig.
7. Maximum Operating Temperature: 330 deg F. F. Flexible Connectors:

1. Body: Stainless-steel bellows with woven, flexible, stainless-steel-wirereinforced protective jacket.
2. End Connections:

   a. NPS 2 and Smaller: With threaded-end connections.
   b. NPS 2-1/2 and Larger: With flanged-end connections.

3. Offset Performance: Capable of minimum 3/4-inch misalignment in minimum 7-inch- long assembly.
4. Pressure Rating: Factory test at minimum 500 psig.
5. Maximum Operating Temperature: 250 deg F.

2.4 VALVES AND SPECIALTIES

A. Diaphragm Packless Valves:
1. Body and Bonnet: Forged brass or cast bronze; globe design with straightthrough or angle pattern.
2. Diaphragm: Phosphor bronze and stainless steel with stainless-steel spring.
3. Operator: Rising stem and hand wheel.
4. Seat: Nylon.
5. End Connections: Socket, union, or flanged.
6. Working Pressure Rating: 500 psig.

7. Maximum Operating Temperature: 275 deg F. B. Packed-Angle Valves:

1. Body and Bonnet: Forged brass or cast bronze.
2. Packing: Molded stem, back seating, and replaceable under pressure.
3. Operator: Rising stem.
4. Seat: Nonrotating, self-aligning polytetrafluoroethylene.
5. Seal Cap: Forged-brass or valox hex cap.
6. End Connections: Socket, union, threaded, or flanged.
7. Working Pressure Rating: 500 psig.
8. Maximum Operating Temperature: 275 deg F.

C. Check Valves:
   1. Body: Ductile iron, forged brass, or cast bronze; globe pattern.
   2. Bonnet: Bolted ductile iron, forged brass, or cast bronze; or brass hex plug.
   3. Piston: Removable polytetrafluoroethylene seat.
   4. Closing Spring: Stainless steel.
   5. Manual Opening Stem: Seal cap, plated-steel stem, and graphite seal.
   6. End Connections: Socket, union, threaded, or flanged.
   7. Maximum Opening Pressure: 0.50 psig.
   8. Working Pressure Rating: 500 psig.
   9. Maximum Operating Temperature: 275 deg F.

D. Service Valves:
   1. Body: Forged brass with brass cap including key end to remove core.
   2. Core: Removable ball-type check valve with stainless-steel spring.
   3. Seat: Polytetrafluoroethylene.
   4. End Connections: Copper spring.
   5. Working Pressure Rating: 500 psig.

E. Solenoid Valves: Comply with AHRI 760 and UL 429; listed and labeled by a National Recognized Testing Laboratory (NRTL).
   1. Body and Bonnet: Plated steel.
   2. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
   3. Seat: Polytetrafluoroethylene.
   4. End Connections: Threaded.
   5. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch conduit adapter, and **24 or 115**-V ac coil.
   6. Working Pressure Rating: 400 psig.
   7. Maximum Operating Temperature: 240 deg F.

F. Safety Relief Valves: Comply with 2010 ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.

1. Body and Bonnet: Ductile iron and steel, with neoprene O-ring seal.
2. Piston, Closing Spring, and Seat Insert: Stainless steel.
3. Seat: Polytetrafluoroethylene.
4. End Connections: Threaded.
5. Working Pressure Rating: 400 psig.
6. Maximum Operating Temperature: 240 deg F.

G. Thermostatic Expansion Valves: Comply with AHRI 750.
1. Body, Bonnet, and Seal Cap: Forged brass or steel.
2. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
3. Packing and Gaskets: Non-asbestos.
4. Capillary and Bulb: Copper tubing filled with refrigerant charge.
5. Suction Temperature: 40 deg F.
6. Superheat: Adjustable, Nonadjustable.
7. Reverse-flow option (for heat-pump applications).
8. End Connections: Socket, flare, or threaded union.
9. Working Pressure Rating: 700 psig, 450 psig.

H. Hot-Gas Bypass Valves: Comply with UL 429; listed and labeled by an NRTL.
1. Body, Bonnet, and Seal Cap: Ductile iron or steel.
2. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
3. Packing and Gaskets: Non-asbestos.
4. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
5. Seat: Polytetrafluoroethylene.
6. Equalizer: Internal, External.
7. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch conduit adapter and **24** or **115**-V ac coil.
8. End Connections: Socket.
9. Throttling Range: Maximum 5 psig.
10. Working Pressure Rating: 500 psig.
11. Maximum Operating Temperature: 240 deg F.

I. Straight-Type Strainers:
1. Body: Welded steel with corrosion-resistant coating.
2. Screen: 100-mesh stainless steel.
3. End Connections: Socket or flare.
4. Working Pressure Rating: 500 psig.
5. Maximum Operating Temperature: 275 deg F.

J. Angle-Type Strainers:
1. Body: Forged brass or cast bronze.
2. Drain Plug: Brass hex plug.
3. Screen: 100-mesh monel.
4. End Connections: Socket or flare.

5. Working Pressure Rating: 500 psig.
6. Maximum Operating Temperature: 275 deg F.

K. Moisture/Liquid Indicators:
1. Body: Forged brass.
2. Window: Replaceable, clear, fused glass window with indicating element protected by filter screen.
3. Indicator: Color coded to show moisture content in parts per million (ppm).
4. Minimum Moisture Indicator Sensitivity: Indicate moisture above 60 ppm.
5. End Connections: Socket or flare.
6. Working Pressure Rating: 500 psig.
7. Maximum Operating Temperature: 240 deg.

L. Replaceable-Core Filter Dryers: Comply with AHRI 730.
1. Body and Cover: Painted-steel shell with ductile-iron cover, stainless-steel screws, and neoprene gaskets.
2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
3. Desiccant Media: Activated alumina, charcoal.
4. Designed for reverse flow (for heat-pump applications).
5. End Connections: Socket.
6. Access Ports: NPS 1/4 (DN 8) connections at entering and leaving sides for pressure differential measurement.
7. Maximum Pressure Loss: 2 psig.
8. Working Pressure Rating: 500 psig.
9. Maximum Operating Temperature: 240 deg F.

M. Permanent Filter Dryers: Comply with AHRI 730.
1. Body and Cover: Painted-steel shell.
2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
3. Desiccant Media: Activated alumina, charcoal.
4. Designed for reverse flow (for heat-pump applications).
5. End Connections: Socket.
6. Access Ports: NPS 1/4 connections at entering and leaving sides for pressure differential measurement.
7. Maximum Pressure Loss: 2 psig.
8. Working Pressure Rating: 500 psig.
9. Maximum Operating Temperature: 240 deg F.

N. Mufflers:
1. Body: Welded steel with corrosion-resistant coating.
2. End Connections: Socket or flare.
3. Working Pressure Rating: 500 psig.

4. Maximum Operating Temperature: 275 deg F.

O. Receivers: Comply with AHRI 495.
1. Comply with 2010 ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.
2. Comply with UL 207; listed and labeled by an NRTL.
3. Body: Welded steel with corrosion-resistant coating.
4. Tappings: Inlet, outlet, liquid level indicator, and safety relief valve.
5. End Connections: Socket or threaded.
6. Working Pressure Rating: 500 psig.
7. Maximum Operating Temperature: 275 deg F.

P. Liquid Accumulators: Comply with AHRI 495.
1. Body: Welded steel with corrosion-resistant coating.
2. End Connections: Socket or threaded.
3. Working Pressure Rating: 500 psig.
4. Maximum Operating Temperature: 275 deg F.

2.5 REFRIGERANTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Atofina Chemicals, Inc.
2. DuPont Company; Fluorochemicals Div.
3. Honeywell, Inc.; Genetron Refrigerants.
4. INEOS Fluor Americas LLC.

B. ASHRAE 34, R-410A: Pentafluoroethane/Difluoromethane.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS FOR REFRIGERANT R-410A

A. Suction Lines NPS 1-1/2 and Smaller for Conventional Air-Conditioning Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed or soldered joints.

B. Suction Lines NPS 3-1/2 and Smaller for Conventional Air-Conditioning Applications: Copper, Type ACR, Type L, drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.

C. Suction Lines NPS 4 and Smaller for Conventional Air-Conditioning Applications: Copper, Type ACR, Type K, Type L, drawn-temper tubing and wrought-copper fittings with soldered joints.

D. Hot-Gas and Liquid Lines and Suction Lines for Heat-Pump Applications: Copper, Type ACR, Type L, annealed- or drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.

E. Hot-Gas and Liquid Lines and Suction Lines for Heat-Pump Applications: Copper, Type K, annealed- or drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.

F. Hot-Gas and Liquid Lines and Suction Lines for Heat-Pump Applications: Copper, Type ACR, Type K, Type L, drawn-temper tubing and wrought-copper fittings with 95-5 tin-antimony soldered joints.

G. Hot-Gas and Liquid Lines and Suction Lines for Heat-Pump Applications: Copper, Type ACR, Type K, Type L, drawn-temper tubing and wrought-copper fittings with Alloy HB soldered joints.

H. Hot-Gas and Liquid Lines and Suction Lines for Heat-Pump Applications:

1. NPS 5/8 and Smaller: Copper, Type AC, Type L, annealed- or drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.
2. NPS 3/4 to NPS 1 and Smaller: Copper, Type K, annealed- or drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.
3. NPS 1-1/4 and Smaller: Copper, Type ACR, Type K, Type L, drawn-temper tubing and wrought-copper fittings with 95-5 tin-antimony soldered joints.
4. NPS 1-1/2 to NPS 2: Copper, Type ACR, Type K, Type L, drawn-temper tubing and wrought-copper fittings with Alloy HB soldered joints.

I. Hot-Gas and Liquid Lines and Suction Lines for Heat-Pump Applications NPS 2 to NPS 4: Schedule 40, black-steel and wrought-steel fittings with welded joints.

J. Safety-Relief-Valve Discharge Piping: Copper, Type ACR, Type L, annealed- or drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.

K. Safety-Relief-Valve Discharge Piping: Copper, Type K, annealed- or drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.

L. Safety-Relief-Valve Discharge Piping: Copper, Type ACR, Type K, Type L, drawntemper tubing and wrought-copper fittings with 95-5 tin-antimony soldered joints.

M. Safety-Relief-Valve Discharge Piping: Copper, Type ACR, Type K, Type L, drawntemper tubing and wrought-copper fittings with Alloy HB soldered joints. N. Safety-Relief-Valve Discharge Piping:

1. NPS 5/8 and Smaller: Copper, Type ACR, Type L, annealed- or drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.
2. NPS 3/4 to NPS 1 and Smaller: Copper, Type K, annealed- or drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.
3. NPS 1-1/4 and Smaller: Copper, Type ACR, Type K, Type L, drawn-temper tubing and wrought-copper fittings with 95-5 tin-antimony soldered joints.
4. NPS 1-1/2 to NPS 2: Copper, Type ACR, Type K, Type L, drawn-temper tubing and wrought-copper fittings with Alloy HB soldered joints.

O. Safety-Relief-Valve Discharge Piping NPS 2 to NPS 4: Schedule 40, black-steel and wrought-steel fittings with welded joints.

3.2 VALVE AND SPECIALTY APPLICATIONS

A. Install diaphragm packless, packed-angle valves in suction and discharge lines of compressor.

B. Install service valves for gage taps at inlet and outlet of hot-gas bypass valves and strainers if they are not an integral part of valves and strainers.

C. Install a check valve at the compressor discharge and a liquid accumulator at the compressor suction connection.

D. Except as otherwise indicated, install diaphragm packless, packed-angle valves on inlet and outlet side of filter dryers.

E. Install a full-size, three-valve bypass around filter dryers.

F. Install solenoid valves upstream from each expansion valve and hot-gas bypass valve. Install solenoid valves in horizontal lines with coil at top.

G. Install thermostatic expansion valves as close as possible to distributors on evaporators.

1. Install valve so diaphragm case is warmer than bulb.
2. Secure bulb to clean, straight, horizontal section of suction line using two bulb straps. Do not mount bulb in a trap or at bottom of the line.
3. If external equalizer lines are required, make connection where it will reflect suction-line pressure at bulb location.

H. Install safety relief valves where required by 2010 ASME Boiler and Pressure Vessel Code. Pipe safety-relief-valve discharge line to outside according to ASHRAE 15.

I. Install moisture/liquid indicators in liquid line at the inlet of the thermostatic expansion valve or at the inlet of the evaporator coil capillary tube.

J. Install strainers upstream from and adjacent to the following unless they are furnished as an integral assembly for the device being protected:

1. Solenoid valves.
2. Thermostatic expansion valves.
3. Hot-gas bypass valves.
4. Compressor.

K. Install filter dryers in liquid line between compressor and thermostatic expansion valve and in the suction line at the compressor.

L. Install receivers sized to accommodate pump-down charge.

M. Install flexible connectors at compressors.

3.3 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems; indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop Drawings.

B. Install refrigerant piping according to ASHRAE 15.

C. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping adjacent to machines to allow service and maintenance.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. Select system components with pressure rating equal to or greater than system operating pressure.

J. Refer to Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC" for solenoid valve controllers, control wiring, and sequence of operation.

K. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.

L. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels as specified in Section 083113 "Access Doors and Frames" if valves or equipment requiring maintenance is concealed behind finished surfaces.

M. Install refrigerant piping in protective conduit where installed belowground.

N. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.

O. Slope refrigerant piping as follows:

1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
2. Install horizontal suction lines with a uniform slope downward to compressor.
3. Install traps and double risers to entrain oil in vertical runs.
4. Liquid lines may be installed level.

P. When brazing or soldering, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.

Q. Before installation of steel refrigerant piping, clean pipe and fittings using the following procedures:

1. Shot blast the interior of piping.
2. Remove coarse particles of dirt and dust by drawing a clean, lintless cloth through tubing by means of a wire or electrician's tape.
3. Draw a clean, lintless cloth saturated with trichloroethylene through the tube or pipe. Continue this procedure until cloth is not discolored by dirt.

4. Draw a clean, lintless cloth, saturated with compressor oil, squeezed dry, through the tube or pipe to remove remaining lint. Inspect tube or pipe visually for remaining dirt and lint.
5. Finally, draw a clean, dry, lintless cloth through the tube or pipe.
6. Safety-relief-valve discharge piping is not required to be cleaned but is required to be open to allow unrestricted flow.

R. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.

S. Identify refrigerant piping and valves according to Section 230553 "Identification for HVAC Piping and Equipment."

T. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

U. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

V. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

3.4 PIPE JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Fill pipe and fittings with an inert gas (nitrogen or carbon dioxide), during brazing or welding, to prevent scale formation.

D. Soldered Joints: Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook."

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Chapter "Pipe and Tube."

1. Use Type BCuP (copper-phosphorus) alloy for joining copper socket fittings with copper pipe.

2. Use Type BAg (cadmium-free silver) alloy for joining copper with bronze or steel.

F. Threaded Joints: Thread steel pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and to restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry-seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

G. Steel pipe can be threaded, but threaded joints must be seal brazed or seal welded.

H. Welded Joints: Construct joints according to AWS D10.12M/D10.12.

I. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.5 HANGERS AND SUPPORTS

A. Comply with requirements for pipe hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment." B.

Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet long.
2. Roller hangers and spring hangers for individual horizontal runs 20 feet or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.
5. Copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.

C. Install hangers for copper tubing with the following maximum spacing and minimum rod diameters:

1. NPS 1/2: Maximum span, 60 inches; minimum rod, 1/4 inch.
2. NPS 5/8: Maximum span, 60 inches; minimum rod, 1/4 inch.
3. NPS 1: Maximum span, 72 inches; minimum rod, 1/4 inch.

4. NPS 1-1/4: Maximum span, 96 inches; minimum rod, 3/8 inch. 5. NPS 1-1/2: Maximum span, 96 inches; minimum rod, 3/8 inch.
6. NPS 2: Maximum span, 96 inches; minimum rod, 3/8 inch.
7. NPS 2-1/2: Maximum span, 108 inches; minimum rod, 3/8 inch.
8. NPS 3: Maximum span, 10 feet; minimum rod, 3/8 inch.
9. NPS 4: Maximum span, 12 feet; minimum rod, 1/2 inch.

D. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 2: Maximum span, 10 feet; minimum rod, 3/8 inch.
2. NPS 2-1/2: Maximum span, 11 feet; minimum rod, 3/8 inch.
3. NPS 3: Maximum span, 12 feet; minimum rod, 3/8 inch.
4. NPS 4: Maximum span, 14 feet; minimum rod, 1/2 inch. E. Support

multifloor vertical runs at least at each floor.

3.6 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Comply with ASME B31.5, Chapter VI.
2. Test refrigerant piping, specialties, and receivers. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.
3. Test high- and low-pressure side piping of each system separately at not less than the pressures indicated in "Performance Requirements" Article.

    a. Fill system with nitrogen to the required test pressure.
    b. System shall maintain test pressure at the manifold gage throughout duration of test.
    c. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.
    d. Remake leaking joints using new materials, and retest until satisfactory results are achieved.

B. Prepare test and inspection reports.

3.7 SYSTEM CHARGING

A. Charge system using the following procedures:

1. Install core in filter dryers after leak test but before evacuation.
2. Evacuate entire refrigerant system with a vacuum pump to 500 micrometers (67 Pa). If vacuum holds for 12 hours, system is ready for charging.
3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig (14 kPa).
4. Charge system with a new filter-dryer core in charging line.

3.8 ADJUSTING

A. Adjust thermostatic expansion valve to obtain proper evaporator superheat.

B. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.

C. Adjust set-point temperature of air-conditioning or chilled-water controllers to the system design temperature.

D. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:

1. Open shutoff valves in condenser water circuit.
2. Verify that compressor oil level is correct.
3. Open compressor suction and discharge valves.
4. Open refrigerant valves except bypass valves that are used for other purposes.
5. Check open compressor-motor alignment and verify lubrication for motors and bearings.

E. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

END OF SECTION

SECTION 232923
VARIABLE-FREQUENCY CONTROLLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes solid-state, PWM, VFCs for speed control of three-phase, squirrel-cage induction motors.

B. Related Sections include the following:

1. Division 26 for monitoring and control of motor circuits.
2. Division 26 for low-voltage power, control, and communication surge suppressors.

1.3 DEFINITIONS

A. BMS: Building management system.

B. IGBT: Integrated gate bipolar transistor.

C. LAN: Local area network.

D. PID: Control action, proportional plus integral plus derivative.

E. PWM: Pulse-width modulated.

F. VFC: Variable frequency controller.

1.4 SUBMITTALS

A. Compliance to IEEE 519 – harmonic analysis for particular jobsite including total harmonic voltage distortion and total harmonic current distortion (TDD).

1. The VFC manufacturer shall provide calculations; specific to this installation, showing total harmonic voltage distortion is less than 5%. Input line filters shall be sized and provided as required by the VFC manufacturer to ensure compliance with IEEE standard 519. All VFCs shall include a minimum of 5% impedance reactors, no exceptions.

    a. The calculations shall be performed using the harmonics analysis software SKM Power Tools for Windows Hi-Wave module or similar type analysis software. The intent is to include the entire electrical distribution system impedance in the harmonics analysis.

    b. The Point of Common Coupling shall be the main switchboard or switchgear for the building.

B. Product Data: For each type of VFC. Include dimensions, mounting arrangements, location for conduit entries, shipping and operating weights, and manufacturer's technical data on features, performance, electrical ratings, characteristics, and finishes.

C. Shop Drawings: For each VFC.

1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings. Include the following:

   a. Each installed unit's type and details.

   b. Nameplate legends.

   c. Short-circuit current rating of integrated unit.

   d. Listed and labeled for series rating of overcurrent protective devices in combination controllers by an NRTL acceptable to authorities having jurisdiction.

   e. Features, characteristics, ratings, and factory settings of each motorcontrol center unit.

2. Wiring Diagrams: Power, signal, and control wiring for VFCs. Provide schematic wiring diagram for each type of VFC.

D. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout, required working clearances, and required area above and around VFCs where pipe and ducts are prohibited. Show VFC layout and relationships between electrical components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate field measurements.

E. Manufacturer Seismic Qualification Certification: Submit certification that VFCs, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

   a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

F. Qualification Data

1. VFCs and options shall be UL listed as a complete assembly. VFCs that require the customer to supply external fuses for the VFC to be UL listed are not acceptable. The base VFC shall be UL listed for 100 KAIC without the need for input fuses.

2. CE Mark – The VFC shall conform to the European Union Electromagnetic Compatibility directive, a requirement for CE marking. The VFC shall meet product standard EN 61800-3 for the First Environment restricted level.

3. The VFC manufacturer shall have available a comprehensive, HVAC Drive Computer Based Training (CBT) product. The CBT product shall include detailed, interactive sections covering VFC 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. G. Field quality-control test reports.

H. Operation and Maintenance Data: For VFCs, all installed devices, and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Routine maintenance requirements for VFCs and all installed components.

I. Load-Current and Overload-Relay Heater List: Compile after motors have been installed and arrange to demonstrate that selection of heaters suits actual motor nameplate full-load currents.

J. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed and arrange to demonstrate that dip switch settings for motor running overload protection suit actual motor to be protected.

1.5 QUALITY ASSURANCE

A. Manufacturer Qualifications: A qualified manufacturer. Maintain, within 100 miles of Project site, a service center capable of providing training, parts, and emergency maintenance and repairs.

B. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the International Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

1. Testing Agency's Field Supervisor: Person currently certified by the International Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

C. Source Limitations: Obtain VFCs of a single type through one source from a single manufacturer.

D. 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. E. Comply with NFPA 70.

F. Product Selection for Restricted Space: Drawings indicate maximum dimensions for VFCs, minimum clearances between VFCs, and adjacent surfaces and other items. Comply with indicated maximum dimensions and clearances.

G. Referenced Standards:

1. Institute of Electrical and Electronic Engineers (IEEE)
   a. Standard 519-1992, IEEE Guide for Harmonic Content and Control.
2. Underwriters laboratories
   a. UL508C
3. National Electrical Manufacturer's Association (NEMA)
   a. ICS 7.0, AC Adjustable Speed Drives
4. IEC 16800 Parts 1 and 2

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver VFCs in shipping splits of lengths that can be moved past obstructions in delivery path as indicated.

B. Store VFCs indoors in clean, dry space with uniform temperature to prevent condensation. Protect VFCs from exposure to dirt, fumes, water, corrosive substances, and physical damage.

C. If stored in areas subject to weather, cover VFCs to protect them from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside controllers; install electric heating of sufficient wattage to prevent condensation.

1.7 PROJECT CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation, capable of driving full load without de-rating, under the following conditions, unless otherwise indicated:
   1. Ambient Temperature: 0 to 40 deg C.
   2. Humidity: Less than 90 percent (non-condensing).
   3. Altitude: Not exceeding 3300 feet.

B. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:
   1. Notify Owner, Architect, and Construction Manager no less than one week in advance of proposed interruption of electrical service.
   2. Indicate method of providing temporary electrical service.
   3. Do not proceed with interruption of electrical service without written permission.

C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for VFCs, including clearances between VFCs, and adjacent surfaces and other items. Comply with indicated maximum dimensions.

1.8 COORDINATION

A. Coordinate layout and installation of VFCs with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03 Section "Cast-in-Place Concrete."

C. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."

D. Coordinate features of VFCs, installed units, and accessory devices with pilot devices and control circuits to which they connect.

E. Coordinate features, accessories, and functions of each VFC and each installed unit with ratings and characteristics of supply circuit, motor, required control sequence, and duty cycle of motor and load.

1.9 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Spare Fuses: Furnish one spare for every five installed, but no less than one set of three of each type and rating.
2. Indicating Lights: Two of each type installed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. ABB, Inc. (Preferable manufacturer)
2. Yaskawa
3. Danfoss Inc.; Danfoss Electronic Drives Div.
4. Eaton Corporation; Cutler-Hammer Products.
5. General Electric Company; GE Industrial Systems.
6. Square D.
7. Toshiba International Corporation.

2.2 VARIABLE FREQUENCY CONTROLLERS

A. Description: NEMA ICS 2, IGBT, PWM, VFC; listed and labeled as a complete unit and arranged to provide variable speed of an NEMA MG 1, Design B, 3-phase induction motor by adjusting output voltage and frequency.

1. Provide unit suitable for operation of premium-efficiency motor as defined by NEMA MG 1.

2. VFCs shall be 6 pulse design with 5% input impedance. All components shall be integrally mounted and wired in a single enclosure.

B. Design and Rating: Match load type such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a powertransmission connection.

C. The VFC package as specified herein shall be enclosed in a UL Listed Type 12 enclosure, completely assembled and tested by the manufacturer in an ISO9001 facility. The VFC tolerated voltage window shall allow the VFC to operate from a line of +30% nominal, and -35% nominal voltage as a minimum.

D. Output Rating: 3-phase; 6 to 60 Hz, with voltage proportional to frequency throughout voltage range.

E. Unit Operating Requirements:

1. Input ac voltage tolerance of 208 V, plus or minus 5, 380 to 500 V, plus or minus 10.
2. Input frequency tolerance of 50/60 Hz, plus or minus 6 percent.
3. Minimum Efficiency: 96 percent at 60 Hz, full load.
4. Minimum Displacement Primary-Side Power Factor: 96 percent.
5. Overload Capability: 1.1 times the base load current for 60 seconds; 2.0 times the base load current for 3 seconds.
6. Starting Torque: 100 percent of rated torque or as indicated.
7. Speed Regulation: Plus or minus 1 percent.

F. Isolated control interface to allow controller to follow control signal over an 11:1 speed range.

1. Electrical Signal: 4 to 20 mA at 24 V. G. Internal Adjustability Capabilities:
    1. Minimum Speed: 5 to 25 percent of maximum rpm.
    2. Maximum Speed: 80 to 100 percent of maximum rpm.
    3. Acceleration: 2 to a minimum of 22 seconds.
    4. Deceleration: 2 to a minimum of 22 seconds.
    5. Current Limit: 50 to a minimum of 110 percent of maximum rating. H.

Self-Protection and Reliability Features:

1. Input transient protection.
    a. The VFC shall include a coordinated AC transient protection system consisting of 4-120 joule rated MOVs (phase to phase and phase to ground), a capacitor clamp, and 5% impedance reactors.
2. Under- and overvoltage trips; inverter over temperature, overload, and overcurrent trips.

3. Motor Overload Relay: Adjustable and capable of NEMA ICS 2, Class [**10**] [**20**] [**30**] performance.
4. Notch filter to prevent operation of the controller-motor-load combination at a natural frequency of the combination.
5. Three (3) programmable critical frequency lockout ranges to prevent the VFC from operating the load continuously at an unstable speed.
6. Instantaneous line-to-line and line-to-ground overcurrent trips.
7. Loss-of-phase protection.
8. Reverse-phase protection.
9. Short-circuit protection.
10. Motor over temperature fault.

I. Multiple-Motor Capability: Controller suitable for service to multiple motors and having a separate overload relay and protection for each controlled motor. Overload relay shall shut off controller and motors served by it when overload relay is tripped.

J. Automatic Reset/Restart: Attempts three restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction. Bidirectional autopsied search shall be capable of starting into rotating loads spinning in either direction and returning motor to set speed in proper direction, without damage to controller, motor, or load.

K. Power-Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped.

L. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.

M. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.

N. Input Line Conditioning

1. The VFC 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. VFCs with only one DC reactor shall add AC line reactors.

O. VFC Output Filtering: The VFC shall be constructed to limit output voltage spikes. Include an output DV/DT filter to limit voltage spikes at the motor. The filter shall be housed integral to the VFC or in an enclosure adjacent to the VFC.

P. Status Lights: Door-mounted LED indicators shall indicate the following conditions:

1. Power on.
2. Run.
3. Overvoltage.

4. Line fault.
5. Overcurrent.
6. External fault.

Q. Panel-Mounted Operator Station (Keypad): Start-stop and auto-manual selector switches with manual speed control potentiometer and elapsed time meter.

R. Indicating Devices: Meters or digital readout devices and selector switch, mounted flush in controller door and connected to indicate the following controller parameters:

1. Output frequency (Hz).
2. Motor speed (rpm).
3. Motor status (running, stop, fault).
4. Motor current (amperes).
5. Motor torque (percent).
6. Fault or alarming status (code).
7. PID feedback signal (percent).
8. DC-link voltage (VDC).
9. Set-point frequency (Hz). 10. Motor output voltage (V). S. Control Signal Interface:

1. Electric Input Signal Interface: A minimum of 2 analog inputs (0 to 10 V or 0/4-20 mA) and 6 programmable digital inputs.
2. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the BMS or other control systems:
   a. 0 to 10-V dc.
   b. 0-20 or 4-20 mA.
   c. Potentiometer using up/down digital inputs.
   d. Fixed frequencies using digital inputs.
   e. RS485.
   f. Keypad display for local hand operation.
3. Output Signal Interface:
   a. A minimum of 1 analog output signal (0/4-20 mA), which can be programmed to any of the following:
      1) Output frequency (Hz).
      2) Output current (load).
      3) DC-link voltage (VDC).
      4) Motor torque (percent).

5) Motor speed (rpm).

6) Set-point frequency (Hz).

4. Remote Indication Interface: A minimum of 2 dry circuit relay outputs (120-V ac, 1 A) for remote indication of the following:

a. Motor running.

b. Set-point speed reached.

c. Fault and warning indication (over temperature or overcurrent).

d. PID high- or low-speed limits reached.

T. Communications

1. The VFC 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 VFC. 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 (BASC). 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.

c. Device Management – Dynamic Device Binding (Who-Is; I-AM).

d. Device Management – Dynamic Object Binding (Who-Has; I-Have).

e. Device Management – Communication Control – B.

f. If additional hardware is required to obtain the BACnet interface, the VFC manufacturer shall supply one BACnet gateway per drive. Multiple VFCs sharing one gateway shall not be acceptable.

3. 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 VFC 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 VFC 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 VFC mode or bypass mode (if bypass is specified) over serial communications. A minimum of 15 field parameters shall be capable of being monitored.

4. The VFC shall allow the DDC to control the drive's digital and analog outputs via the serial interface. This control shall be independent of any VFC 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.

5. The VFC 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 VFC control PID loop and the independent PID loop shall continue functioning even if the serial communications connection is lost. The VFC shall keep the last good setpoint command and last good DO & AO commands in memory in the event the serial communications connection is lost.

U. Manual Bypass and Control Features

1. All features to be furnished and mounted by the drive manufacturer. All features shall be UL Listed by the drive manufacturer as a complete assembly and carry a UL508 label.

2. A complete factory wired and tested bypass system consisting of an output contactor and bypass contactor. Overload protection and shall be provided in both drive and bypass modes.

3. Door interlocked, padlockable circuit breaker that will disconnect all input power from the drive and all internally mounted options.

4. Fused VFC only disconnect (service switch). Fast acting fuses exclusive to the VFC – fast acting fuses allow the VFC to disconnect from the line prior to clearing upstream branch circuit protection, maintaining bypass capability. Bypass designs, which have no such fuses, or that incorporate fuses common to both the VFC and the bypass will not be accepted. Three contactor bypass schemes are not acceptable.

5. The drive / bypass shall provide single-phase motor protection in both the VFC and bypass modes.

6. The following operators shall be provided:

    a. Bypass Hand-Off-Auto

    b. Drive mode selector

    c. Bypass mode selector

    d. Bypass fault reset

7. The following indicating lights (LED type) shall be provided. A test mode or push to test feature shall be provided.
    a. Power-on (Ready)
    b. Run enable (safeties) open
    c. Drive mode select damper opening
    d. Bypass mode selected
    e. Drive running
    f. Bypass running
    g. Drive fault
    h. Bypass fault
    i. Bypass H-O-A mode
    j. Automatic transfer to bypass selected
    k. Safety open
    l. Damper opening
    m. Damper end-switch made
8. The following relay (form C) outputs from the bypass shall be provided:
    a. System started
    b. System running
    c. Bypass override enabled
    d. Drive fault
    e. Bypass fault (motor overload or underload (broken belt))
    f. Bypass H-O-A position
9. The digital inputs for the system shall accept 24V or 115VAC (selectable). The bypass shall incorporate internally sourced power supply and not require an external control power source.
10. Customer Interlock Terminal Strip – provide a separate terminal strip for connection of freeze, fire, smoke contacts, and external start command. All external safety interlocks shall remain fully functional whether the system is in Hand, Auto, or Bypass modes (not functional in Fireman’s Override 2). The remote start/stop contact shall operate in VFC and bypass modes.
11. Dedicated digital input that will transfer motor from VFC mode to bypass mode upon dry contact closure for fireman’s override. Two modes of operation are required.
    a. One mode forces the motor to bypass operation and overrides both the VFC and bypass H-O-A switches and forces the motor to operate across the line (test mode). The system will only respond to the digital inputs and motor protections.

b. The second fireman's override mode remains as above, but will also defeat the overload and single-phase protection for bypass and ignore all keypad and digital inputs to the system (run until destruction).

12. The VFC shall include a "run permissive circuit" that will provide a normally open contact whenever a run command is provided (local or remote start command in VFC or bypass mode). The VFC system (VFC or bypass) shall not operate the motor until it receives a dry contact closure from a damper or

valve end-switch. When the VFC system safety interlock (fire detector, freezestat, high static pressure switch, etc) opens, the motor shall coast to a stop and the run permissive contact shall open, closing the damper or valve.

13. Class 20 or 30 (selectable) electronic motor overload protection shall be included.

14. There shall be an internal switch to select manual or automatic bypass.

15. There shall be an adjustable current sensing circuit for the bypass to provide loss of load indication (broken belt) when in the bypass mode.

2.3 ENCLOSURES

A. The VFC package as specified herein shall be enclosed in a UL listed Type 12 enclosure, completely assembled and tested by the manufacturer in an ISO9001 facility. The VFC tolerated voltage window shall allow the VFC to operate from a line of +30 percent nominal voltage as a minimum.

2.4 ACCESSORIES

A. Devices shall be factory installed in controller enclosure, unless otherwise indicated.

B. Push-Button Stations, Pilot Lights, and Selector Switches: NEMA ICS 2, heavy-duty type.

C. Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open.

D. Control Relays: Auxiliary and adjustable time-delay relays.

E. Standard Displays:

1. Output frequency (Hz).
2. Set-point frequency (Hz).
3. Motor current (amperes).
4. DC-link voltage (VDC).
5. Motor torque (percent).
6. Motor speed (rpm).
7. Motor output voltage (V).

F. Historical Logging Information and Displays:

1. Real-time clock with current time and date.

2. Running log of total power versus time.
3. Total run time.
4. Fault log, maintaining last four faults with time and date stamp for each.

G. Current-Sensing, Phase-Failure Relays for Bypass Controller: Solid-state sensing circuit with isolated output contacts for hard-wired connection; arranged to operate on phase failure, phase reversal, current unbalance of from 30 to 40 percent, or loss of supply voltage; with adjustable response delay.

2.5 FACTORY FINISHES

A. Finish: Manufacturer's standard paint applied to factory-assembled and -tested VFCs before shipping.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, surfaces, and substrates to receive VFCs for compliance with requirements, installation tolerances, and other conditions affecting performance.

B. Examine roughing-in for conduit systems to verify actual locations of conduit connections before VFC installation.

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

3.2 APPLICATIONS

A. Select features of each VFC to coordinate with ratings and characteristics of supply circuit and motor; required control sequence; and duty cycle of motor, controller, and load.

B. Select horsepower rating of controllers to suit motor controlled.

3.3 INSTALLATION

A. Anchor each VFC assembly to steel-channel sills arranged and sized according to manufacturer's written instructions. Attach by bolting. Level and grout sills flush with mounting surface.

B. Install VFCs on concrete bases.

C. Comply with mounting and anchoring requirements specified in Division 26 Section "Hangers and Supports for Electrical Systems."

D. Controller Fuses: Install fuses in each fusible switch. Comply with requirements in Division 26 Section "Fuses."

3.4 CONCRETE BASES

A. Coordinate size and location of concrete bases. Verify structural requirements with structural engineer.

B. Concrete base is specified in Division 26 Section "Common Work Results for Electrical," and concrete materials and installation requirements are specified in Division 03.

3.5 IDENTIFICATION

A. Identify VFCs, components, and control wiring according to Division 26 Section "Identification for Electrical Systems."

B. Operating Instructions: Frame printed operating instructions for VFCs, including control sequences and emergency procedures. Fabricate frame of finished metal, and cover instructions with clear acrylic plastic. Mount on front of VFC units.

3.6 CONTROL WIRING INSTALLATION

A. Install wiring between VFCs and remote devices according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

B. Bundle, train, and support wiring in enclosures.

C. Connect hand-off-automatic switch and other automatic-control devices where applicable.

1. Connect selector switches to bypass only manual- and automatic-control devices that have no safety functions when switch is in hand position.

2. Connect selector switches with control circuit in both hand and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

3.7 CONNECTIONS

A. Conduit installation requirements are specified in other Division 26 Sections. Drawings indicate general arrangement of conduit, fittings, and specialties.

B. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

3.8 FIELD QUALITY CONTROL

A. Prepare for acceptance tests as follows:

1. Test insulation resistance for each enclosed controller element, bus, component, connecting supply, feeder, and control circuit.

2. Test continuity of each circuit.

B. Manufacturer's Field Service: 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 owner, and a copy kept on file at the manufacturer.

1. Inspect controllers, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.

2. Assist in field testing of equipment including pretesting and adjusting of solidstate controllers.

3. Report results in writing.

C. Warranty

1. Warranty shall be 24 months from the date of certified start-up, not to exceed 30 months from the date of shipment. The warranty shall include all parts, labor,

travel time and expenses. There shall be 365/24 support available via a toll free phone number.

D. Testing Agency: Engage a qualified testing and inspecting agency to perform the following field tests and inspections and prepare test reports:

E. Perform the following field tests and inspections and prepare test reports:

1. Perform each electrical test and visual and mechanical inspection, except optional tests, stated in NETA ATS. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

3.9 ADJUSTING

A. Set field-adjustable switches and circuit-breaker trip ranges.

3.10 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain variable frequency controllers. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION

SECTION 233113
METAL DUCTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Single-wall rectangular ducts and fittings.
2. Single-wall round ducts and fittings.
3. Sheet metal materials.
4. Duct liner.
5. Sealants and gaskets.
6. Hangers and supports.
7. Seismic-restraint devices. B. Related Sections:

1. Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing requirements for metal ducts.
2. Section 233116 "Nonmetal Ducts" for fibrous-glass ducts, thermoset fiberreinforced plastic ducts, thermoplastic ducts, PVC ducts, and concrete ducts.
3. Section 233119 "HVAC Casings" for factory- and field-fabricated casings for mechanical equipment.
4. Section 233300 "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.3 DEFINITIONS

A. OSHPD: Office of Statewide Health Planning and Development (State of California).

1.4 ACTION SUBMITTALS

A. Product Data: For each type of the following products:

1. Liners and adhesives.
2. Sealants and gaskets.
3. Seismic-restraint devices.

B. Shop Drawings:

1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
2. Factory- and shop-fabricated ducts and fittings.
3. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.
4. Elevation of top and bottom of ducts.
5. Dimensions of all duct runs from building grid lines.
6. Fittings.
7. Reinforcement and spacing.
8. Seam and joint construction.
9. Penetrations through fire-rated and other partitions.
10. Equipment installation based on equipment being used on Project.
11. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
12. Hangers and supports, including methods for duct and building attachment, seismic restraints, and vibration isolation. C. Delegated-Design Submittal:

1. Sheet metal thicknesses.
2. Joint and seam construction and sealing.
3. Reinforcement details and spacing.
4. Materials, fabrication, assembly, and spacing of hangers and supports.
5. Design Calculations: Calculations, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation for selecting hangers and supports and seismic restraints.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: A single set of plans or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.

1. 1. Duct installation in congested spaces, indicating coordination with general construction, building components, and other building services. Indicate proposed changes to duct layout.
   a. Suspended ceiling components.
   b. Structural members to which duct will be attached.
   c. Size and location of initial access modules for acoustical tile.
   d. Penetrations of smoke barriers and fire-rated construction.
   e. Items penetrating finished ceiling including the following:
      1. Lighting fixtures.
      2. Air outlets and inlets.
      3. Speakers.

4. Sprinklers.
5. Access panels.
6. Perimeter moldings.

B. Welding certificates.

C. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel in accordance with the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.
2. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum," for aluminum supports.
3. AWS D9.1/D9.1M, "Sheet Metal Welding Code," for duct joint and seam welding.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."

C. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and with performance requirements and design criteria indicated in "Duct Schedule" Article.

B. Structural Performance: Duct hangers and supports **and seismic restraints** shall withstand the effects of gravity **and seismic** loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" **and ASCE/SEI 7,** Seismically brace duct hangers and supports in accordance with, **SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems.", SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems - OSHPD Edition."**

1. Seismic Hazard Level (SHL): [**AA**] [**A**] [**B**] [**C**] [**D**].
2. Connection Level: [**1**] [**2**].

3. Seismic Hazard Level A: Seismic force to weight ratio, 0.48.
4. Seismic Hazard Level B: Seismic force to weight ratio, 0.30. 5. Seismic Hazard Level C: Seismic force to weight ratio, 0.15.

C. Airstream Surfaces: Surfaces in contact with airstream shall comply with requirements in ASHRAE 62.1.

D. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment," and Section 7 - "Construction and System Startup."

E. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

F. Duct Dimensions: Unless otherwise indicated, all duct dimensions indicated on Drawings are inside clear dimensions and do not include insulation or duct wall thickness.

2.2 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

1. Construct ducts of galvanized sheet steel unless otherwise indicated.

B. Transverse Joints: Fabricate joints in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. For ducts with longest side less than 36 inches, select joint types in accordance with Figure 2-1.
2. For ducts with longest side 36 inches or greater, use flange joint connector Type T-22, T-24, T-24A, T-25a, or T-25b. Factory-fabricated flanged duct connection system may be used if submitted and approved by engineer of record.

C. Longitudinal Seams: Select seam types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible." All longitudinal seams shall be Pittsburgh lock seams unless otherwise specified for specific application.

D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 4, "Fittings and Other Construction," for staticpressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.3 SINGLE-WALL ROUND DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.

1. Construct ducts of galvanized sheet steel unless otherwise indicated.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. McGill AirFlow LLC.
    b. Sheet Metal Connectors, Inc.
    c. Lindab Inc.
    d. SEMCO Incorporated.
    e. Spiral Manufacturing Co., Inc.

B. Transverse Joints: Select joint types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.

C. Longitudinal Seams: Select seam types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.
2. Fabricate flat-oval ducts larger than 72 inches in width (major dimension) with butt-welded longitudinal seams.

D. Tees and Laterals: Select types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.4 SHEET METAL MATERIALS

A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
   1. Galvanized Coating Designation: G60, G90.
   2. Finishes for Surfaces Exposed to View: Mill phosphatized.

C. PVC-Coated, Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.

   1. Galvanized Coating Designation: G60, G90.
   2. Minimum Thickness for Factory-Applied PVC Coating: 4 mils thick on sheet metal surface of ducts and fittings exposed to corrosive conditions, and minimum 1 mil thick on opposite surface.
   3. Coating Materials: Acceptable to authorities having jurisdiction for use on ducts listed and labeled by an NRTL for compliance with UL 181, Class 1.

D. Carbon-Steel Sheets: Comply with ASTM A 1008/A 1008M, with oiled, matte finish for exposed ducts.

E. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304 or 316, as indicated in "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in "Duct Schedule" Article.

F. Aluminum Sheets: Comply with ASTM B 209 Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.

G. Factory- or Shop-Applied Antimicrobial Coating:

   1. Apply to the surface of sheet metal that will form the interior surface of the duct. An untreated clear coating shall be applied to the exterior surface.
   2. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
   3. Coating containing the antimicrobial compound shall have a hardness of 2H, minimum, when tested in accordance with ASTM D 3363.
   4. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested in accordance with UL 723; certified by an NRTL.
   5. Shop-Applied Coating Color: Black or White.
   6. Antimicrobial coating on sheet metal is not required for duct containing liner treated with antimicrobial coating.

H. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

   1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.

I. Tie Rods: Galvanized steel, 1/4-inch- minimum diameter for lengths 36 inches or less; 3/8-inch- minimum diameter for lengths longer than 36 inches.

2.5 DUCT LINER

A. Fiberglass-Free Duct Liner: Made from partially recycled cotton or polyester products and containing no fiberglass. Airstream surface overlaid with fire-resistant facing to prevent surface erosion by airstream, complying with NFPA 90A or NFPA 90B. Treat natural-fiber products with antimicrobial coating.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Bonded Logic, Inc.
    b. Reflectix Inc.

2. Maximum Thermal Conductivity: 0.24 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature when tested in accordance with ASTM C 518.
3. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested in accordance with ASTM E 84; certified by an NRTL.
4. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.
    a. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
    b. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using

SmallScale Environmental Chambers." B. Insulation Pins and Washers:

1. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch- diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
2. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick galvanized steel, aluminum, and stainless steel; with beveled edge sized as required to hold insulation securely in place, but not less than 1-1/2 inches in diameter.

C. Shop Application of Duct Liner: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 7-11, "Flexible Duct Liner Installation."

1. Adhere a single layer of indicated thickness of duct liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of duct liner is prohibited.
2. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.
3. Butt transverse joints without gaps, and coat joint with adhesive.
4. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.

5. Do not apply liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and dimensions of standard liner make longitudinal joints necessary.
6. Apply adhesive coating on longitudinal seams in ducts with air velocity of 2500 fpm or greater.
7. Secure liner with mechanical fasteners 4 inches from corners and at intervals not exceeding 12 inches transversely; at 3 inches from transverse joints and at intervals not exceeding 18 inches longitudinally.
8. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from duct wall. Fabricate edge facings at the following locations:

   a. Fan discharges.
   b. Intervals of lined duct preceding unlined duct.
   c. Upstream edges of transverse joints in ducts where air velocities are higher than 2500 fpm or where indicated.

9. Secure insulation between perforated sheet metal inner duct of same thickness as specified for outer shell. Use mechanical fasteners that maintain inner duct at uniform distance from outer shell without compressing insulation.

   a. Sheet Metal Inner Duct Perforations: 3/32-inch diameter, with an overall open area of 23 percent.

10. Terminate inner ducts with buildouts attached to fire-damper sleeves, dampers, turning vane assemblies, or other devices. Fabricated buildouts (metal hat sections) or other buildout means are optional; when used, secure buildouts to duct walls with bolts, screws, rivets, or welds.

2.6 SEALANT AND GASKETS

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested in accordance with UL 723; certified by an NRTL.

B. Two-Part Tape Sealing System:

1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
2. Tape Width: 6 inches.
3. Sealant: Modified styrene acrylic.
4. Water resistant.
5. Mold and mildew resistant.
6. Maximum Static-Pressure Class: 10 inch wg, positive and negative.
7. Service: Indoor and outdoor.
8. Service Temperature: Minus 40 to plus 200 deg F.

9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.
10. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
11. Sealant shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. Water-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Solids Content: Minimum 65 percent.
3. Shore A Hardness: Minimum 20.
4. Water resistant.
5. Mold and mildew resistant.
6. VOC: Maximum 75 g/L (less water).
7. Maximum Static-Pressure Class: 10 inch wg, positive and negative.
8. Service: Indoor or outdoor.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets. D. Solvent-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Base: Synthetic rubber resin.
3. Solvent: Toluene and heptane.
4. Solids Content: Minimum 60 percent.
5. Shore A Hardness: Minimum 60.
6. Water resistant.
7. Mold and mildew resistant.
8. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
9. VOC: Maximum 395 g/L.
10. Sealant shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
11. Maximum Static-Pressure Class: 10-inch wg, positive or negative.
12. Service: Indoor or outdoor.
13. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

E. Flanged Joint Sealant: Comply with ASTM C 920.

1. General: Single-component, acid-curing, silicone, elastomeric.
2. Type: S.
3. Grade: NS.

4. Class: 25.
5. Use: O.
6. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealant shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

F. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

G. Round Duct Joint O-Ring Seals:

1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg and shall be rated for10-inch wg static-pressure class, positive or negative.
2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.7 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Galvanized-steel rods and nuts.

B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."

D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.

E. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A 492.

F. Steel Cable End Connections: Galvanized-steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

G. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials. H. Trapeze and Riser Supports:

1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
2. Supports for Stainless-Steel Ducts: Stainless-steel shapes and plates.
3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

2.8 SEISMIC-RESTRAINT DEVICES

A. Manufacturers: Subject to compliance with requirements, [provide products by one of the following:
   1. Cooper B-Line, Inc.; a division of Cooper Industries.
   2. Ductmate Industries, Inc.
   3. Hilti Corp.
   4. Kinetics Noise Control.
   5. Loos & Co.; Cableware Division.
   6. Mason Industries.
   7. TOLCO; a brand of NIBCO INC.
   8. Unistrut Corporation; Tyco International, Ltd.

B. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an evaluation service member of the ICC Evaluation Service, OSHPD, in State of California and an agency acceptable to authorities having jurisdiction.

   1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four] times the maximum seismic forces to which they will be subjected.

C. Channel Support System: Shop- or field-fabricated support assembly made of slotted steel channels rated in tension, compression, and torsion forces and with accessories for attachment to braced component at one end and to building structure at the other end. Include matching components and corrosion-resistant coating.

D. Restraint Cables: ASTM A 603, galvanized, ASTM A 492, stainless]-steel cables with end connections made of galvanized-steel assemblies with brackets, swivel, and bolts designed for restraining cable service; and with an automatic-locking and clamping device or double-cable clips.

E. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections, Reinforcing steel angle clamped to hanger rod.

F. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type. Select anchor bolts with strength required for anchor and as tested in accordance with ASTM E 488/E 488M.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and coordination drawings.

B. Install ducts in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.

C. Install ducts in maximum practical lengths with fewest possible joints.

D. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

E. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

F. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

G. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.

H. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

I. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.

J. Install fire combination fire/smoke,]and smoke dampers where indicated on Drawings and as required by code, and by local authorities having jurisdiction. Comply with requirements in Section 233300 "Air Duct Accessories" for fire and smoke dampers and specific installation requirements of the damper UL listing.

K. Install heating coils, cooling coils, air filters, dampers, and all other duct-mounted accessories in air ducts where indicated on Drawings.

L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials both before and after installation. Comply with SMACNA's "IAQ Guidelines for Occupied Buildings Under Construction," Appendix G, "Duct Cleanliness for New Construction Guidelines."

M. Elbows: Use long-radius elbows wherever they fit.

1. Fabricate 90-degree rectangular mitered elbows to include turning vanes.
2. Fabricate 90-degree round elbows with a minimum of three segments for 12 inches and smaller and a minimum of five segments for 14 inches and larger. N. Branch Connections: Use lateral or conical branch connections.

3.2 INSTALLATION OF EXPOSED DUCTWORK

A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.

B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.

C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.

D. Maintain consistency, symmetry, and uniformity in arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.

E. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.3 DUCTWORK EXPOSED TO WEATHER

A. All external joints are to have secure watertight mechanical connections. Seal all openings to provide weatherproof construction.

B. Construct ductwork to resist external loads of wind, snow, ice, and other effects of weather. Provide necessary supporting structures.

C. Single Wall:

1. Ductwork shall be galvanized steel.

   a. If duct outer surface is uninsulated, protect outer surface with suitable paint. Paint materials and application requirements are specified in Section 099113 "Exterior Painting."

2. Where ducts have external insulation, provide weatherproof aluminum jacket. See Section 230713 "Duct Insulation."

3.4 DUCT SEALING

A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

B. Seal ducts at a minimum to the following seal classes in accordance with 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 2Inch 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.

3.5 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structuralsteel fasteners appropriate for construction materials to which hangers are being attached.

1. Where practical, install concrete inserts before placing concrete.
2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
5. Do not use powder-actuated concrete fasteners for seismic restraints.

C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.

D. Hangers Exposed to View: Threaded rod and angle or channel supports.

E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet.

F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.6 SEISMIC-RESTRAINT-DEVICE INSTALLATION

A. Install ducts with hangers and braces designed to support the duct and to restrain against seismic forces required by applicable building codes. Comply with SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems.", SMACNA's "Seismic Restrain Manual: Guidelines for Mechanical Systems - OSHPD Edition.", ASCE/SEI 7.
   1. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.
   2. Brace a change of direction longer than 12 feet.

B. Select seismic-restraint devices with capacities adequate to carry present and future static and seismic loads.

C. Install cables so they do not bend across edges of adjacent equipment or building structure.

D. Install cable restraints on ducts that are suspended with vibration isolators.

E. Install seismic-restraint devices using methods approved by an evaluation service member of the ICC Evaluation Service, OSHPD, and an agency acceptable to authorities having jurisdiction.

F. Attachment to Structure: If specific attachment is not indicated, anchor bracing and restraints to structure, to flanges of beams, to upper truss chords of bar joists, or to concrete members.

G. Drilling for and Setting Anchors:

   1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcement or embedded items during drilling. Notify Architect if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
   2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
   3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
   4. Set anchors to manufacturer's recommended torque, using a torque wrench.
   5. Install zinc-coated steel anchors for interior applications and stainless-steel anchors for applications exposed to weather.

3.7 CONNECTIONS

A. Make connections to equipment with flexible connectors complying with Section 233300 "Air Duct Accessories."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.8 PAINTING

A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."

3.9 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Leakage Tests:

1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.
2. Test the following systems:
    a. Supply Ducts with a Pressure Class of 2- Inch wg or Higher: Test representative duct sections, totaling no less than 100 percent of total installed duct area for each designated pressure class.
    b. Return Ducts with a Pressure Class of 2- Inch wg or Higher: Test representative duct sections, totaling no less than 100 percent of total installed duct area for each designated pressure class.
    c. Exhaust Ducts with a Pressure Class of 2- Inch wg or Higher: Test representative duct sections, totaling no less than 100 percent of total installed duct area for each designated pressure class.
    d. Outdoor-Air Ducts with a Pressure Class of 2- Inch wg or Higher: Test representative duct sections, totaling no less than 100> percent of total installed duct area for each designated pressure class.

3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
4. Testing of each duct section is to be performed with access doors, coils, filters, dampers, and other duct-mounted devices in place as designed. No devices are to be removed or blanked off so as to reduce or prevent additional leakage.
5. Test for leaks before applying external insulation.
6. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
7. Give seven days' advance notice for testing. C. Duct System Cleanliness

    Tests:

1. Visually inspect duct system to ensure that no visible contaminants are present.

2. Test sections of metal duct system, chosen randomly by Owner, for cleanliness in accordance with "Description of Method 3 - NADCA Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."

   a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.

D. Duct system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.10 DUCT CLEANING

A. Clean new duct system(s) before testing, adjusting, and balancing.

B. For cleaning of existing ductwork, see Section 230130.52 "Existing HVAC Air Distribution System Cleaning."

C. Use duct cleaning methodology as indicated in NADCA ACR.

D. Use service openings for entry and inspection.

1. Provide openings with access panels appropriate for duct static-pressure and leakage class at dampers, coils, and any other locations where required for inspection and cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer. Comply with Section 233300 "Air Duct Accessories" for access panels and doors.
2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
3. Remove and reinstall ceiling to gain access during the cleaning process. E.

Particulate Collection and Odor Control:

1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.
2. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.

F. Clean the following components by removing surface contaminants and deposits:

1. Air outlets and inlets (registers, grilles, and diffusers).
2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.

4. Coils and related components.
5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
6. Supply-air ducts, dampers, actuators, and turning vanes.
7. Dedicated exhaust and ventilation components and makeup air systems. G.

Mechanical Cleaning Methodology:

1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.
5. Clean coils and coil drain pans in accordance with NADCA ACR. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
6. Provide drainage and cleanup for wash-down procedures.
7. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents in accordance with manufacturer's written instructions after removal of surface deposits and debris.

3.11 STARTUP

A. Air Balance: Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

3.12 DUCT SCHEDULE

A. Fabricate ducts with galvanized sheet steel except as otherwise indicated and as follows:

1. Fabricate all ducts to achieve SMACNA pressure class, seal class, and leakage class as indicated below. B. Supply Ducts:

1. Ducts Connected to Variable-Air-Volume Air-Handling Units:

   a. Pressure Class: Positive 4-inch wg.
   b. Minimum SMACNA Seal Class: A.

c. SMACNA Leakage Class for Rectangular: 4.
d. SMACNA Leakage Class for Round and Flat Oval: 4.

2. Ducts Connected to the discharge of the Variable and Constant Value Terminal Boxes:

a. Pressure Class: Positive or negative 2- inch wg.
b. Minimum SMACNA Seal Class: A.
c. SMACNA Leakage Class for Rectangular: 2.
d. SMACNA Leakage Class for Round and Flat Oval: 2. C. Return

Ducts:

1. Ducts Connected to Terminal Units:

a. Pressure Class: Positive or negative 2- inch wg.
b. Minimum SMACNA Seal Class: A.
c. SMACNA Leakage Class for Rectangular: 2.
d. SMACNA Leakage Class for Round and Flat Oval: 2.

2. Ducts Connected to Air-Handling Units:

a. Pressure Class: Positive or negative 4 inch wg.
b. Minimum SMACNA Seal Class: A.
c. SMACNA Leakage Class for Rectangular: 4.
d. SMACNA Leakage Class for Round and Flat Oval: 4. D.

Exhaust Ducts:

1. Ducts Connected to Fans Exhausting (ASHRAE 62.1, Class 1 and 2) Air:

a. Pressure Class: Negative 2- inch wg.
b. Minimum SMACNA Seal Class: A if negative pressure, and A if positive pressure.
c. SMACNA Leakage Class for Rectangular: 2.
d. SMACNA Leakage Class for Round and Flat Oval: 2. E. Intermediate

Reinforcement:

1. Galvanized-Steel Ducts: Galvanized steel.

2. Aluminum Ducts: Aluminum. F. Elbow

Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."

a. Velocity 1000 fpm or Lower:

1) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.
2) Mitered Type RE 4 without vanes.

b. Velocity 1000 to 1500 fpm:

1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.
2) Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.
3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

c. Velocity 1500 fpm or Higher:

1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
2) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

2. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."

a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
c. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

3. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "Round Duct Elbows."

a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.

1) Velocity 1000 fpm or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
2) Velocity 1000 to 1500 fpm: 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
3) Velocity 1500 fpm or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow. 4) Radius-to Diameter Ratio: 1.5.

b. Round Elbows, 12 Inches and Smaller in Diameter: Stamped or pleated.

c. Round Elbows, 14 Inches and Larger in Diameter: Standing seam.

G. Branch Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connection."

   a. Rectangular Main to Rectangular Branch: 45-degree entry.
   b. Rectangular Main to Round Branch: Conical spin in.

2. Round and Flat Oval: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees." Saddle taps are permitted in existing duct.

   a. Velocity 1000 fpm or Lower: 90-degree tap.
   b. Velocity 1000 to 1500 fpm: Conical tap.
   c. Velocity 1500 fpm or Higher: 45-degree lateral.

END OF SECTION

SECTION 233300
AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Backdraft and pressure relief dampers.
2. Barometric relief dampers.
3. Manual volume dampers.
4. Control dampers.
5. Fire dampers.
6. Smoke dampers.
7. Combination fire and smoke dampers.
8. Flange connectors.
9. Duct silencers.
10. Turning vanes.
11. Duct-mounted access doors.
12. Flexible connectors.
13. Duct security bars.
14. Duct accessory hardware. B. Related Requirements:

1. Section 233346 "Flexible Ducts" for insulated and non-insulated flexible ducts.
2. Section 233723 "HVAC Gravity Ventilators" for roof-mounted ventilator caps.
3. Section 284621.11 "Addressable Fire-Alarm Systems" for duct-mounted fire and smoke detectors.
4. Section 284621.13 "Conventional Fire-Alarm Systems" for duct-mounted fire and smoke detectors.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. For duct silencers, include pressure drop and dynamic insertion loss data. Include breakout noise calculations for high transmission loss casings.

B. Shop Drawings: For duct accessories. Include plans, elevations, sections, details and attachments to other work.

1. Detail duct accessories fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction.
   Include the following:

   a. Special fittings.
   b. Manual volume damper installations.
   c. Control-damper installations.
   d. Fire-damper, smoke-damper, combination fire- and smoke-damper, ceiling, and corridor damper installations, including sleeves; and ductmounted access doors and remote damper operators.
   e. Duct security bars.
   f. Wiring Diagrams: For power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which ceilingmounted access panels and access doors required for access to duct accessories are shown and coordinated with each other, using input from Installers of the items involved.

B. Source quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fusible Links: Furnish quantity equal to **10** percent of amount installed.

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTION

A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

2.2 MATERIALS

A. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.

1. Galvanized Coating Designation: G60 or G90.
2. Exposed-Surface Finish: Mill phosphatized.

B. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304, and having a No. 2 finish for concealed ducts and finish for exposed ducts.

C. Aluminum Sheets: Comply with ASTM B 209), Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts. D. Extruded Aluminum: Comply with ASTM B 221, Alloy 6063, Temper T6.

E. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainlesssteel ducts.

F. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.3 BACKDRAFT AND PRESSURE RELIEF DAMPERS

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

a. Air Balance Inc.; a division of Mestek, Inc.
b. American Warming and Ventilating; a division of Mestek, Inc.
c. Cesco Products; a division of Mestek, Inc.
d. Greenheck Fan Corporation.
e. Lloyd Industries, Inc.
f. Nailor Industries Inc.
g. NCA Manufacturing, Inc.
h. Pottorff.

i. Ruskin Company.

B. Description: Gravity balanced.

C. Maximum Air Velocity: 1000 fpm and 1250 fpm.

D. Maximum System Pressure: 2-inch wg and 4-inch wg and 6-inch.

E. Frame: Hat-shaped, 0.05-inch-thick, galvanized sheet steel or 0.094-inch-thick, galvanized sheet steel or 0.063-inch-thick extruded aluminum or 0.03-inch-thick stainless steel or 0.05-inch-thick stainless steel, with welded corners or mechanically attached and mounting flange.

F. Blades: Multiple single-piece blades, center pivoted, or end pivoted, maximum 6inch width, 0.025-inch-thick, roll-formed aluminum, 0.050-inch-thick aluminum sheet, noncombustible, tear-resistant, neoprene-coated fiberglass with sealed edges.

G. Blade Action: Parallel.

H. Blade Seals: Felt, Vinyl foam, Extruded vinyl, mechanically locked, or Neoprene, mechanically locked. I. Blade Axles:

1. Material: Nonferrous metal, Galvanized steel, Stainless steel, Aluminum.
2. Diameter: 0.20 inch.

J. Tie Bars and Brackets: Aluminum or Galvanized steel.

K. Return Spring: Adjustable tension.

L. Bearings: Steel ball or synthetic pivot bushings.

M. Accessories:

1. Adjustment device to permit setting for varying differential static pressure.
2. Counterweights and spring-assist kits for vertical airflow installations.
3. Electric actuators.
4. Chain pulls.
5. Screen Mounting: Front mounted in sleeve.
    a. Sleeve Thickness: 20 gage minimum.
    b. Sleeve Length: 6 inches minimum.
6. Screen Mounting: Rear mounted.
7. Screen Material: Galvanized steel or Aluminum.
8. Screen Type: Bird and Insect.
9. 90-degree stops.

2.4 BAROMETRIC RELIEF DAMPERS

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

a. Air Balance Inc.; a division of Mestek, Inc.
b. American Warming and Ventilating; a division of Mestek, Inc.
c. Cesco Products; a division of Mestek, Inc.
d. Greenheck Fan Corporation.
e. Lloyd Industries, Inc.
f. Nailor Industries Inc.
g. NCA Manufacturing, Inc.
h. Pottorff.
i. Ruskin Company.
j. Vent Products Company, Inc.

B. Suitable for horizontal or vertical mounting.

C. Maximum Air Velocity: 1250 fpm or 2000 fpm.

D. Maximum System Pressure: 2-inch wg or 4-inch wg or 6-inch wg.

E. Frame: Hat-shaped, 0.05-inch- thick, galvanized sheet steel, 0.094-inch-thick, galvanized sheet steel, 0.063-inch-thick extruded aluminum, 0.03-inch-thick stainless steel or 0.05-inch-thick stainless steel, with welded corners or mechanically attached and mounting flange. F. Blades:

1. Multiple 0.025-inch- thick, roll-formed aluminum and 0.050-inch-thick aluminum sheet.
2. Maximum Width: 6 inches 3. Action: Parallel.
4. Balance: Gravity.
5. Eccentrically pivoted or End pivoted. G. Blade

Seals: Vinyl or Neoprene.

H. Blade Axles: Galvanized steel. Nonferrous metal, Stainless steel.

I. Tie Bars and Brackets:

1. Material: Aluminum or Galvanized steel.
2. Rattle free with 90-degree stop. J. Return

Spring: Adjustable tension.

K. Bearings: Synthetic, Stainless steel, or Bronze.

L. Accessories:

1. Flange on intake.
2. Adjustment device to permit setting for varying differential static pressures.

2.5 MANUAL VOLUME DAMPERS

A. Standard, Steel, Manual Volume Dampers:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Air Balance Inc.; a division of Mestek, Inc.
b. American Warming and Ventilating; a division of Mestek, Inc.
c. Flexmaster U.S.A., Inc.
d. McGill AirFlow LLC.
e. Nailor Industries Inc.
f. Pottorff.
g. Ruskin Company.
h. Trox USA Inc.
i. Vent Products Company, Inc

2. Standard leakage rating**,** with linkage outside airstream.
3. Suitable for horizontal or vertical applications.
4. Frames:

a. Frame: Hat-shaped, 0.094-inch-thick, galvanized sheet steel, 0.05-inchthick stainless steel.
b. Mitered and welded corners.
c. Flanges for attaching to walls and flangeless frames for installing in ducts.

5. Blades:

a. Multiple or single blade.
b. Parallel- or opposed-blade design.
c. Stiffen damper blades for stability.
d. Galvanized Stainless-steel, 0.064 inch thick.

6. Blade Axles: Galvanized steel, Stainless steel, Nonferrous metal.
7. Bearings:

a. Oil-impregnated bronze, Molded synthetic, oil-impregnated stainlesssteel sleeve, Stainless-steel sleeve.

b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.

8. Tie Bars and Brackets: Galvanized steel.

B. Standard, Aluminum, Manual Volume Dampers:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. Air Balance Inc.; a division of Mestek, Inc.
   b. American Warming and Ventilating; a division of Mestek, Inc.
   c. Flexmaster U.S.A., Inc.
   d. McGill AirFlow LLC.
   e. Nailor Industries Inc.
   f. Pottorff.
   g. Ruskin Company.
   h. Trox USA Inc.
   i. Vent Products Company, Inc

2. Standard leakage rating, with linkage outside airstream.
3. Suitable for horizontal or vertical applications.
4. Frames: Hat-shaped, 0.10-inch- thick, aluminum sheet channels; frames with flanges for attaching to walls and flangeless frames for installing in ducts.
5. Blades:
   a. Multiple or single blade.
   b. Parallel- or opposed-blade design.
   c. Stiffen damper blades for stability.
   d. Roll-Formed Aluminum Blades: 0.10-inch- thick aluminum sheet.
   e. Extruded-Aluminum Blades: 0.050-inch- thick extruded aluminum.

6. Blade Axles: Galvanized steel, Stainless steel, Nonferrous metal.
7. Bearings:
   a. Oil-impregnated bronze, Molded synthetic, Stainless-steel sleeve.
   b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.

8. Tie Bars and Brackets: Aluminum.

C. Low-Leakage, Steel, Manual Volume Dampers:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. Air Balance Inc.; a division of Mestek, Inc.

b. American Warming and Ventilating; a division of Mestek, Inc.
c. McGill AirFlow LLC.
d. Nailor Industries Inc.
e. Pottorff.
f. Ruskin Company.
g. Trox USA Inc.
h. Vent Products Company, Inc

2. Comply with AMCA 500-D testing for damper rating.
3. Low-leakage rating, with linkage outside airstream, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.
4. Suitable for horizontal or vertical applications.
5. Frames:

a. Hat, U or Angle shaped.
b. 0.094-inch-thick, galvanized sheet steel, 0.05-inch-thick stainless steel].
c. Mitered and welded corners.
d. Flanges for attaching to walls and flangeless frames for installing in ducts.

6. Blades:

a. Multiple or single blade.
b. Parallel- or opposed-blade design.
c. Stiffen damper blades for stability.
d. Galvanized, Stainless, roll-formed steel, 0.064 inch thick.

7. Blade Axles: Galvanized steel, Stainless steel, Nonferrous metal.
8. Bearings:

a. Oil-impregnated bronze, Molded synthetic, Oil-impregnated stainlesssteel sleeve, Stainless-steel sleeve.
b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.

9. Blade Seals: Felt, Vinyl, Neoprene.
10. Jamb Seals: Cambered stainless steel or aluminum.
11. Tie Bars and Brackets: Galvanized steel or Aluminum.
12. Accessories:

a. Include locking device to hold single-blade dampers in a fixed position without vibration.

D. Low-Leakage, Aluminum, Manual Volume Dampers:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Air Balance Inc.; a division of Mestek, Inc.

b. American Warming and Ventilating; a division of Mestek, Inc.
c. Flexmaster U.S.A., Inc.
d. McGill AirFlow LLC.
e. Nailor Industries Inc.
f. Pottorff.
g. Ruskin Company.
h. Trox USA Inc.
i. Vent Products Company, Inc

2. Comply with AMCA 500-D testing for damper rating.
3. Low-leakage rating, with linkage outside airstream, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.
4. Suitable for horizontal or vertical applications.
5. Frames: Hat, U or Angle-shaped, 0.10-inch- thick, aluminum sheet channels; frames with flanges for attaching to walls and flangeless frames for installing in ducts.
6. Blades:

   a. Multiple or single blade.
   b. Parallel- or opposed-blade design.
   c. Roll-Formed Aluminum Blades: 0.10-inch- thick aluminum sheet.
   d. Extruded-Aluminum Blades: 0.050-inch- thick extruded aluminum.
7. Blade Axles: Galvanized steel, Stainless steel, Nonferrous metal.
8. Bearings:

   a. Oil-impregnated bronze, Molded synthetic, Oil-impregnated stainlesssteel sleeve, Stainless-steel sleeve.
   b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.

9. Blade Seals: Felt, Vinyl, Neoprene.
10. Jamb Seals: Cambered stainless steel or aluminum.
11. Tie Bars and Brackets: Galvanized steel or Aluminum.
12. Accessories:

   a. Include locking device to hold single-blade dampers in a fixed position without vibration. E. Jackshaft:

1. Size: 0.5-inch or 1-inch diameter.
2. Material: Galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
3. Length and Number of Mountings: As required to connect linkage of each damper in multiple-damper assembly. F. Damper Hardware:

1. Zinc-plated, die-cast core with dial and handle made of 3/32-inch- thick zincplated steel, and a 3/4-inch hexagon locking nut.
2. Include center hole to suit damper operating-rod size.
3. Include elevated platform for insulated duct mounting.

2.6 CONTROL DAMPERS

A. Standard, Steel, Manual Volume Dampers:
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
      a. Air Balance Inc.; a division of Mestek, Inc.
      b. American Warming and Ventilating; a division of Mestek, Inc.
      c. Cesco Products; a division of Mestek, Inc.
      d. Greenheck Fan Corporation.
      e. Lloyd Industries, Inc.
      f. McGill AirFlow LLC.
      g. Metal Form Manufacturing, Inc.
      h. Nailor Industries Inc.
      i. NCA Manufacturing, Inc.
      j. Pottorff.
      k. Ruskin Company.
      l. Vent Products Company, Inc.
      m. Young Regulator Company.

B. Low-leakage rating, with linkage outside airstream, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.

C. Frames:

   1. Hat, U or Angle shaped.
   2. 0.094-inch- thick, galvanized sheet steel, 0.05-inch- thick stainless steel].
   3. Mitered and welded or Interlocking, gusseted corners. D. Blades:

1. Multiple blade with maximum blade width of 6 inches or 8 inches.
2. Parallel, Parallel- and opposed, Opposed -blade design.
3. Galvanized-steel, Stainless steel or Aluminum.
4. 0.064 inch thick single skin or 0.0747-inch-thick dual skin.
5. Blade Edging: Closed-cell neoprene or PVC.
6. Blade Edging: Inflatable seal blade edging, or replaceable rubber seals.

E. Blade Axles: 1/2-inch- diameter; galvanized steel, stainless steel or nonferrous metal; blade-linkage hardware of zinc-plated steel and brass; ends sealed against blade bearings.

1. Operating Temperature Range: From minus 40 to plus 200 deg F.:

2. Oil-impregnated bronze, Molded synthetic or Oil-impregnated stainless-steel sleeve, Stainless-steel sleeve.
3. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
4. Thrust bearings at each end of every blade.

2.7 FIRE DAMPERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. Air Balance Inc.; a division of Mestek, Inc.
   b. American Warming and Ventilating; a division of Mestek, Inc.
   c. Cesco Products; a division of Mestek, Inc.
   d. Greenheck Fan Corporation.
   e. Lloyd Industries, Inc.
   f. McGill AirFlow LLC.
   g. Metal Form Manufacturing, Inc.
   h. Nailor Industries Inc.
   i. NCA Manufacturing, Inc.
   j. Pottorff.
   k. Ruskin Company.
   l. Vent Products Company, Inc.
   m. Young Regulator Company.

B. Type: Static and dynamic; rated and labeled according to UL 555 by an NRTL.

C. Closing rating in ducts up to 4-inch wg static pressure class and minimum 2000fpm velocity.

D. Fire Rating: **1-1/2 and 3** hours.

E. Frame: Curtain type with blades inside airstream, Curtain type with blades outside airstream, Multiple-blade type or Curtain type with blades outside airstream except when located behind grille where blades may be inside airstream; fabricated with roll-formed, 0.034-inch- thick galvanized steel; with mitered and interlocking corners.

F. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel.

   1. Minimum Thickness: 0.05 inch or 0.138 inch thick, as indicated, and of length to suit application.
   2. Exception: Omit sleeve where damper-frame width permits direct attachment of perimeter mounting angles on each side of wall or floor;

thickness of damper frame must comply with sleeve requirements. G. Mounting Orientation: Vertical or horizontal as indicated.

H. Blades: Roll-formed, interlocking, 0.024-inch- or 0.034-inch- thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch- thick, galvanized-steel blade connectors.

I. Horizontal Dampers: Include blade lock and stainless-steel closure spring.

J. Heat-Responsive Device: Replaceable, 165 deg F or 212 deg F rated, fusible links.

K. Heat-Responsive Device: Electric, resettable or replaceable link and switch package, factory installed, 165 deg F and 212 deg F rated.

2.8 SMOKE DAMPERS

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

a. Air Balance Inc.; a division of Mestek, Inc.
b. Cesco Products; a division of Mestek, Inc.
c. Greenheck Fan Corporation.
d. Nailor Industries Inc.
e. Pottorff.
f. Ruskin Company.

B. General Requirements: Label according to UL 555S by an NRTL.
C. Smoke Detector: Integral, factory wired for single-point connection.

D. Frame: Hat-shaped, 0.094-inch- thick, galvanized sheet steel, with welded, interlocking, gusseted or mechanically attached corners and mounting flange.

E. Blades: Roll-formed, horizontal, interlocking, overlapping, 0.034-inch- or 0.063inch- thick, galvanized sheet steel. F. Leakage: Class I or Class II.

G. Rated pressure and velocity to exceed design airflow conditions.

H. Mounting Sleeve: Factory-installed, 0.039-inch- or 0.05-inch- thick, galvanized sheet steel; length to suit wall or floor application with factory-furnished silicone calking.

I. Damper Motors: Modulating or two-position action.

J. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."
3. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
4. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf and breakaway torque rating of 150 in. x lbf.
5. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F.
6. Nonspring-Return Motors: For dampers larger than 25 sq. ft., size motor for running torque rating of 150 in. x lbf and breakaway torque rating of 300 in. x lbf.
7. Electrical Connection: **20V or 115 V**, single phase, 60 Hz K. Accessories:

1. Auxiliary switches for signaling, fan control or position indication.
2. Momentary test switch, Test and reset switches, damper remote mounted.

2.9 COMBINATION FIRE AND SMOKE DAMPERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. Air Balance Inc.; a division of Mestek, Inc.
   b. Cesco Products; a division of Mestek, Inc.
   c. Greenheck Fan Corporation.
   d. Nailor Industries Inc.
   e. Pottorff.
   f. Ruskin Company.

B. Type: Dynamic; rated and labeled according to UL 555 and UL 555S by an NRTL.

C. Closing rating in ducts up to 4-inch wg static pressure class and minimum 2000fpm velocity.

D. Fire Rating: 1-1/2 and 3 hours.

E. Frame: Hat-shaped, 0.094-inch- thick, galvanized sheet steel, with welded, interlocking, gusseted or mechanically attached corners and mounting flange.

F. Heat-Responsive Device: Resettable, Replaceable, 165 deg F and 212 deg F rated, fusible links or fire-closure device.

G. Heat-Responsive Device: **Electric** resettable link device and switch package, factory installed, rated.

H. Smoke Detector: Integral, factory wired for single-point connection.

I. Blades: Roll-formed, horizontal, interlocking, overlapping, 0.063-inch- or 0.034inch-thick, galvanized sheet steel. J. Leakage: Class I or Class II.

K. Rated pressure and velocity to exceed design airflow conditions.

L. Mounting Sleeve: Factory-installed, 0.039-inch- or 0.05-inch- thick, galvanized sheet steel; length to suit wall or floor application with factory-furnished silicone calking.

M. Master control panel for use in dynamic smoke-management systems.

N. Damper Motors: Modulating or two-position action.

O. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."
3. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
4. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf and breakaway torque rating of 150 in. x lbf.
5. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F.
6. Nonspring-Return Motors: For dampers larger than 25 sq. ft., size motor for running torque rating of 150 in. x lbf and breakaway torque rating of 300 in. x lbf.
7. Electrical Connection: **20 or 115 V**, single phase, 60 Hz. P. Accessories:

1. Auxiliary switches for signaling, fan control or position indication.
2. Momentary test switch, Test and reset switches, damper remote mounted.

2.10 FLANGE CONNECTORS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. Ductmate Industries, Inc.
   b. Nexus PDQ; Division of Shilco Holdings Inc.
   c. Ward Industries, Inc.; a division of Hart & Cooley, Inc

B. Description: Add-on or roll-formed, factory-fabricated, slide-on transverse flange connectors, gaskets, and components. C. Material: Galvanized steel.

D. Gage and Shape: Match connecting ductwork.

2.11 DUCT SILENCERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. Dynasonics.
   b. Industrial Noise Control, Inc.
   c. McGill AirFlow LLC.
   d. Price Industries, Inc.
   e. Vibro-Acoustics. B. General Requirements:

1. Factory fabricated.
2. Hospital Grade
3. Fire-Performance Characteristics: Adhesives, sealants, packing materials, and accessory materials shall have flame-spread index not exceeding 25 and smoke-developed index not exceeding 50 when tested according to ASTM E 84.
4. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1. C. Shape:

1. Rectangular straight with splitters or baffles.
2. Round straight with center bodies or pods.
3. Rectangular elbow with splitters or baffles.
4. Round elbow with center bodies or pods.
5. Rectangular transitional with splitters or baffles.

D. Rectangular Silencer Outer Casing: ASTM A 653/A 653M, G90 or G60, galvanized sheet steel, 0.034 inch or 0.040 inch thick.

E. Round Silencer Outer Casing: ASTM A 653/A 653M, G90 or G60, galvanized sheet steel.

1. Sheet Metal Thickness for Units up to 24 Inches in Diameter: 0.034 inch thick.

2. Sheet Metal Thickness for Units 26 through 40 Inches in Diameter: 0.040 inch thick.
3. Sheet Metal Thickness for Units 42 through 52 Inches in Diameter: 0.05 inch thick.
4. Sheet Metal Thickness for Units 54 through 60 Inches in Diameter: 0.064 inch thick.

F. Inner Casing and Baffles: ASTM A 653/A 653M, G90 or G60 galvanized sheet metal, 0.034 inch thick, and with 1/8-inch- diameter perforations. G.

Special Construction:

1. Suitable for outdoor use.
2. High transmission loss to achieve STC 45.

H. Connection Sizes: Match connecting ductwork unless otherwise indicated.

I. Principal Sound-Absorbing Mechanism:
1. Controlled impedance membranes and broadly tuned resonators without absorptive media.
2. Film-lined type with fill material.

    a. Fill Material: Inert and vermin-proof fibrous material, packed under not less than 5 percent compression, Inert and vermin-proof fibrous material, packed under not less than 15 percent compression and Moisture-proof nonfibrous material.
    b. Erosion Barrier: Polymer bag enclosing fill, and heat sealed before assembly.

3. Lining: Mylar or Tedlar.

J. Fabricate silencers to form rigid units that will not pulsate, vibrate, rattle, or otherwise react to system pressure variations. Do not use mechanical fasteners for unit assemblies.

1. Joints: Lock formed and sealed, continuously welded or flanged connections.
2. Suspended Units: Factory-installed suspension hooks or lugs attached to frame in quantities and spaced to prevent deflection or distortion.
3. Reinforcement: Cross or trapeze angles for rigid suspension. K. Accessories:

1. Integral 1-1/2-hour fire damper with access door. Access door to be high transmission loss to match silencer.
2. Factory-installed end caps to prevent contamination during shipping.
3. Removable splitters.
4. Airflow measuring devices.

L. Source Quality Control: Test according to ASTM E 477.

1. Testing to be witnessed by Architect and Owner.
2. Record acoustic ratings, including dynamic insertion loss and generated-noise power levels with an airflow of at least 2000-fpm face velocity.
3. Leak Test: Test units for airtightness at 200 percent of associated fan static pressure or 6-inch wg static pressure, whichever is greater. M. Capacities and Characteristics:

1. Configuration: Straight or 90-degree elbow.
2. Shape: Rectangular or Round.
3. Attenuation Mechanism: Acoustical glass fiber, Acoustical glass fiber with protective film liner, Helmholtz resonator mechanism with no internal media.
4. Maximum Pressure Drop: 0.35-inch wg.
5. Casing:
    a. Attenuation: Standard or High transmission loss.
    b. Outer Material: Galvanized steel, Stainless steel or Aluminum.
    c. Inner Material: Galvanized steel, Stainless steel or Aluminum.
6. Accessories:
    a. Access door.
    b. Birdscreen.

2.12 TURNING VANES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
    a. Ductmate Industries, Inc.
    b. Duro Dyne Inc.
    c. Elgen Manufacturing.
    d. METALAIRE, Inc.
    e. SEMCO Incorporated.
    f. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

B. Manufactured Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

1. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.

C. Manufactured Turning Vanes for Nonmetal Ducts: Fabricate curved blades of resinbonded fiberglass with acrylic polymer coating; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

D. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 4-3, "Vanes and Vane Runners," and 4-4, "Vane Support in Elbows."

E. Vane Construction: Double wall.

F. Vane Construction: Single wall for ducts up to 48 inches wide and double wall for larger dimensions.

2.13 DUCT-MOUNTED ACCESS DOORS

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

a. American Warming and Ventilating; a division of Mestek, Inc.
b. Cesco Products; a division of Mestek, Inc.
c. Ductmate Industries, Inc.
d. Elgen Manufacturing.
e. Flexmaster U.S.A., Inc.
f. Greenheck Fan Corporation.
g. McGill AirFlow LLC.
h. Nailor Industries Inc.
i. Pottorff.
j. Ventfabrics, Inc.
k. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

B. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 7-2, "Duct Access Doors and Panels," and 7-3, "Access Doors - Round Duct."

1. Door:

a. Double wall, rectangular.
b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
c. Vision panel.
d. Hinges and Latches: 1-by-1-inch butt or piano hinge and cam latches.
e. Fabricate doors airtight and suitable for duct pressure class.

2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
3. Number of Hinges and Locks:

a. Access Doors Less Than 12 Inches Square: No hinges and two sash locks.
b. Access Doors up to 18 Inches Square: Two hinges and Continuous and two sash locks.

c. Access Doors up to 24 by 48 Inches: Three hinges and Continuous and two compression latches with outside and inside handles.
d. Access Doors Larger Than 24 by 48 Inches: Four hinges and Continuous and two compression latches with outside and inside handles. C. Pressure Relief Access Door:

1. Door and Frame Material: Galvanized sheet steel.
2. Door: Single wall and Double wall with insulation fill with metal thickness applicable for duct pressure class.
3. Operation: Open outward for positive-pressure ducts and inward for negativepressure ducts.
4. Factory set at 3.0- to 8.0-inch wg and 10-inch wg.
5. Doors close when pressures are within set-point range.
6. Hinge: Continuous piano.
7. Latches: Cam.
8. Seal: Neoprene or foam rubber.
9. Insulation Fill: 1-inch- thick, fibrous-glass or polystyrene-foam board.

2.14 DUCT ACCESS PANEL ASSEMBLIES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
a. Ductmate Industries, Inc.
b. Flame Gard, Inc.
c. 3M.

B. Labeled according to UL 1978 by an NRTL.

C. Panel and Frame: Minimum thickness 0.0528-inch carbon or 0.0428-inch stainless steel.

D. Fasteners: Carbon or Stainless steel. Panel fasteners shall not penetrate duct wall.

E. Gasket: Comply with NFPA 96; grease-tight, high-temperature ceramic fiber, rated for minimum 2000 deg F.

F. Minimum Pressure Rating: 10-inch wg, positive or negative.

2.15 FLEXIBLE CONNECTORS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
a. Ductmate Industries, Inc.

b. Ductmate Industries, Inc.
c. Duro Dyne Inc.
d. Elgen Manufacturing.
e. Ventfabrics, Inc.
f. Ward Industries, Inc.; a division of Hart & Cooley, Inc B.

Materials: Flame-retardant or noncombustible fabrics.

C. Coatings and Adhesives: Comply with UL 181, Class 1.

D. Metal-Edged Connectors: Factory fabricated with a fabric strip 3-1/2 inches or 53/4 inches wide attached to two strips of 2-3/4-inch- wide, 0.028-inch- thick, galvanized sheet steel or 0.032-inch- thick aluminum sheets. Provide metal compatible with connected ducts.

E. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.

1. Minimum Weight: 26 oz./sq. yd.
2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
3. Service Temperature: Minus 40 to plus 200 deg F.

F. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.

1. Minimum Weight: 24 oz./sq. yd.
2. Tensile Strength: 530 lbf/inch in the warp and 440 lbf/inch in the filling.
3. Service Temperature: Minus 50 to plus 250 deg F.

G. High-Temperature System, Flexible Connectors: Glass fabric coated with silicone rubber.

1. Minimum Weight: 16 oz./sq. yd.
2. Tensile Strength: 285 lbf/inch in the warp and 185 lbf/inch in the filling.
3. Service Temperature: Minus 67 to plus 500 deg F.

H. High-Corrosive-Environment System, Flexible Connectors: Glass fabric with chemical-resistant coating.

1. Minimum Weight: 14 oz./sq. yd.
2. Tensile Strength: 450 lbf/inch in the warp and 340 lbf/inch in the filling.
3. Service Temperature: Minus 67 to plus 500 deg F.

I. Thrust Limits: Combination coil spring and elastomeric insert with spring and insert in compression, and with a load stop. Include rod and angle-iron brackets for attaching to fan discharge and duct.

1. Frame: Steel, fabricated for connection to threaded rods and to allow for a maximum of 30 degrees of angular rod misalignment without binding or reducing isolation efficiency.
2. Outdoor Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
7. Coil Spring: Factory set and field adjustable for a maximum of 1/4-inch movement at start and stop.

2.16 DUCT SECURITY BARS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. Carnes.
   b. KEES, Inc.
   c. Lloyd Industries, Inc.
   d. Metal Form Manufacturing, Inc.
   e. Price Industries.

B. Description: Field-fabricated, Factory-fabricated and field-installed, Field- or factory-fabricated and field-installed duct security bars. C. Configuration:

1. Frame: 2 by 1/4 inch flat frame or 2-1/2 by 2-1/2 by 1/4 inch angle.
2. Sleeve: 0.1345-inch or 3/16-inch, continuously welded or bent steel frames with 1-by-1-by-3/16-inch or 1-1/2-by-1-1/2-by-1/8-inch angle frame factory welded to 1 end or furnished loose for field welding on other end. To be poured in place or set with concrete block or welded or bolted to wall, one side only. Duct connections on both sides.
3. Horizontal Bars: 1/2 inch or 2 by 1/4 inch.
4. Vertical Bars: 1/2 inch, 3/4 inch or 1 inch.
5. Bar Spacing: 6 inches
6. Mounting: Metal deck or roofing, Bolted or welded, Bolted or welded with masonry anchors, Ductwork or other framing, Poured in place or set with concrete block, Welded or bolted to one wall (one side only or Bar extends 6 inches into wall.

2.17 DUCT ACCESSORY HARDWARE

A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.

B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.

B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.

C. Compliance with ASHRAE/IESNA 90.1-2004 includes Section 6.4.3.3.3 - "Shutoff Damper Controls," restricts the use of backdraft dampers, and requires control dampers for certain applications. Install backdraft or control dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.

D. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.

1. Install steel volume dampers in steel ducts.
2. Install aluminum volume dampers in aluminum ducts.

E. Set dampers to fully open position before testing, adjusting, and balancing.

F. Install test holes at fan inlets and outlets and elsewhere as indicated.
G. Install fire and smoke dampers according to UL listing.

H. Install duct security bars. Construct duct security bars from 0.164-inch steel sleeve, continuously welded at all joints and 1/2-inch- diameter steel bars, 6 inches o.c. in each direction in center of sleeve. Weld each bar to steel sleeve and each crossing bar. Weld 2-1/2-by-2-1/2-by-1/4-inch steel angle to 4 sides and both ends of sleeve. Connect duct security bars to ducts with flexible connections. Provide 12by-12-inch hinged access panel with cam lock in duct in each side of sleeve. I. Connect ducts to duct silencers rigidly.

J. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:

1. On both sides of duct coils.
2. Upstream and downstream from duct filters.
3. At outdoor-air intakes and mixed-air plenums.
4. At drain pans and seals.
5. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.
6. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
7. At each change in direction and at maximum 50-foot spacing.
8. Upstream and downstream from turning vanes.
9. Upstream or downstream from duct silencers.
10. Control devices requiring inspection.
11. Elsewhere as indicated.

K. Install access doors with swing against duct static pressure.

L. Access Door Sizes:

1. One-Hand or Inspection Access: 8 by 5 inches.
2. Two-Hand Access: 12 by 6 inches.
3. Head and Hand Access: 18 by 10 inches.
4. Head and Shoulders Access: 21 by 14 inches.
5. Body Access: 25 by 14 inches.
6. Body plus Ladder Access: 25 by 17 inches.

M. Label access doors according to Section 230553 "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.

N. Install flexible connectors to connect ducts to equipment.

O. For fans developing static pressures of 5-inch wg and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

P. Connect terminal units to supply ducts directly or with maximum 12-inch lengths of flexible duct. Do not use flexible ducts to change directions.

Q. Connect diffusers or light troffer boots to ducts directly or with maximum 60-inch lengths of flexible duct clamped or strapped in place.

R. Connect flexible ducts to metal ducts with adhesive, liquid adhesive plus tape, draw bands or adhesive plus sheet metal screws.

S. Install duct test holes where required for testing and balancing purposes.

T. Install thrust limits at centerline of thrust, symmetrical on both sides of equipment. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch movement during start and stop of fans.

3.2 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Operate dampers to verify full range of movement.
2. Inspect locations of access doors and verify that purpose of access door can be performed.
3. Operate fire, smoke, and combination fire and smoke dampers to verify full range of movement and verify that proper heat-response device is installed.
4. Inspect turning vanes for proper and secure installation.
5. Operate remote damper operators to verify full range of movement of operator and damper.

END OF SECTION

SECTION 233416
CENTRIFUGAL HVAC FANS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes: For each product.
   1. Backward-inclined centrifugal fans.

1.3 ACTION SUBMITTALS

A. Product Data:

   1. Include rated capacities, furnished specialties, and accessories for each fan.
   2. Certified fan performance curves with system operating conditions indicated.
   3. Certified fan sound-power ratings.
   4. Motor ratings and electrical characteristics, plus motor and electrical accessories.
   5. Material thickness and finishes, including color charts.
   6. Dampers, including housings, linkages, and operators. B. Shop Drawings:

   1. Include plans, elevations, sections, and attachment details.
   2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   3. Include diagrams for power, signal, and control wiring.
   4. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
   5. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base weights.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show fan room layout and relationships between components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate and certify field measurements.

B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For centrifugal fans to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Belts: One set(s) for each belt-driven unit.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS A.

AMCA Compliance:

1. Comply with AMCA performance requirements and bear the AMCA-Certified Ratings Seal.
2. Operating Limits: Classify according to AMCA 99.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Capacities and Characteristics:
1. Class: I or II or III.
2. Housing Material: Reinforced steel, Aluminum or Stainless steel.
3. Special Housing Coating: Thermoplastic vinyl, Epoxy, Zinc, Synthetic resin, Phenolic, Color-match enamel, Polytetrafluoroethylene, Vinyl ester, Hot-dip galvanized, Powder-baked enamel.
4. Wheel Material: Steel, Aluminum, One-piece fiberglass-reinforced plastic or Stainless steel.
5. Special Wheel Coating: Thermoplastic vinyl, Epoxy, Zinc, Synthetic resin, Phenolic, Color-match enamel, Polytetrafluoroethylene, Vinyl ester, Hot-dip galvanized, Powder-baked enamel.
6. Drive Type: Belt or Direct.
7. Motor:
   a. Motor Enclosure: Open, dripproof, Totally enclosed, fan cooled, Totally enclosed, air over, Open, externally ventilated, Totally enclosed, nonventilated, Severe duty, Explosion proof, Dust-ignition-proof machine.
   b. Enclosure Materials: Cast iron, Cast aluminum or Rolled steel.
8. Vibration Isolators: Spring or Restrained spring isolators having a static deflection of 1 inch.

9. Spark-Resistance Class: A, B or C.

2.2 BACKWARD-INCLINED CENTRIFUGAL FANS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   1. Acme Engineering & Mfg. Corp.
   2. Aerovent; a Twin City Fan company.
   3. Central Blower Company.
   4. Chicago Blower Corporation.
   5. Cincinnati Fan.
   6. CML Northern Blower Inc.
   7. Howden Buffalo Inc.
   8. Loren Cook Company.
   9. New York Blower Company (The). B. Description:

1. Factory-fabricated, -assembled, -tested, and -finished, belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor, drive assembly, and support structure.
2. Deliver fans as factory-assembled units, to the extent allowable by shipping limitations.
3. Factory-installed and -wired disconnect switch. C. Housings:

1. Formed panels to make curved-scroll housings with shaped cutoff.
2. Panel Bracing: Steel angle- or channel-iron member supports for mounting and supporting fan scroll, wheel, motor, and accessories.
3. Horizontally split, bolted-flange housing.
4. Spun inlet cone with flange.
5. Outlet flange.

D. Backward-Inclined Wheels:

1. Single-width-single-inlet and double-width-double-inlet construction with curved inlet flange, backplate, backward-inclined blades, and fastened to shaft with set screws.
2. Welded or riveted to flange and backplate; cast-iron or cast-steel hub riveted to

   backplate. E. Shafts:

1. Statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with adjustable alignment and belt tensioning.
2. Turned, ground, and polished hot-rolled steel with keyway. Ship with protective coating of lubricating oil.
3. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.

F. Prelubricated and Sealed Shaft Bearings:

1. Self-aligning, pillow-block-type ball bearings.
2. Ball-Bearing Rating Life: ABMA 9, Ll0 at 50,000 or 120,000 hours.
3. Roller-Bearing Rating Life: ABMA 11, Ll0 at 50,000 or 120,000 hours.

G. Grease-Lubricated Shaft Bearings:

1. Self-aligning, pillow-block-type, tapered roller bearings with double-locking collars and two-piece, cast-iron housing.
2. Ball-Bearing Rating Life: ABMA 9, Ll0 at 50,000 or 120,000 hours.
3. Roller-Bearing Rating Life: ABMA 11, Ll0 at 50,000 or 120,000 hours. H.

Grease-Lubricated Shaft Bearings:

1. Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing.
2. Ball-Bearing Rating Life: ABMA 9, Ll0 at 50,000 or 120,000 hours. RollerBearing Rating Life: ABMA 11, Ll0 at 50,000 or 120,000 hours. I. Belt Drives:

1. Factory mounted, with adjustable alignment and belt tensioning.
2. Service Factor Based on Fan Motor Size: 1.5.
3. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
4. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
5. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
6. Belt Guards: Fabricate to comply with OSHA and SMACNA requirements of diamond-mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short circuiting vibration isolation. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.
7. Motor Mount: Adjustable for belt tensioning. J. Accessories:

1. Access for Inspection, Cleaning, and Maintenance: Comply with requirements in ASHRAE 62.1.
2. Scroll Drain Connection: NPS 1 steel pipe coupling welded to low point of fan scroll.
3. Companion Flanges: Rolled flanges for duct connections of same material as housing.
4. Variable Inlet Vanes: With blades supported at both ends with two permanently lubricated bearings of same material as housing. Variable mechanism terminating in single control lever with control shaft for doublewidth fans.
5. Discharge Dampers: Assembly with parallel or opposed blades constructed of two plates formed around and to shaft, channel frame, and sealed ball bearings;

with blades linked outside of airstream to single control lever of same material as housing.

6. Inlet Screens: Grid screen of same material as housing.
7. Shaft Cooler: Metal disk between bearings and fan wheel, designed to dissipate heat from shaft.
8. Spark-Resistant Construction: AMCA 99.
9. Shaft Seals: Airtight seals installed around shaft on drive side of single-width fans.
10. Weather Cover: Enameled-steel sheet with ventilation slots, bolted to housing.

2.3 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

2.4 SOURCE QUALITY CONTROL

A. Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.

B. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings according to AMCA 210/ASHRAE 51, "Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install centrifugal fans level and plumb.

B. Disassemble and reassemble units, as required for moving to the final location, according to manufacturer's written instructions.

C. Lift and support units with manufacturer's designated lifting or supporting points.

D. Equipment Mounting:

1. Install centrifugal fans on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete" and Section 033053 "Miscellaneous Cast-in-Place Concrete."

2. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

E. Curb Support: Install roof curb on roof structure, level and secure, according to "The NRCA Roofing and Waterproofing Manual," Low-Slope Membrane Roofing Construction Details Section, Illustration "Raised Curb Detail for Rooftop Air Handling Units and Ducts." Install and secure centrifugal fans on curbs, and coordinate roof penetrations and flashing with roof construction. Secure units to curb support with anchor bolts.

F. Unit Support: Install centrifugal fans level on structural curbs or pilings. Coordinate wall penetrations and flashing with wall construction. Secure units to structural support with anchor bolts.

G. Isolation Curb Support: Install centrifugal fans on isolation curbs, and install flexible duct connectors and vibration isolation and seismic-control devices.

1. Comply with requirements in Section 233300 "Air Duct Accessories" for flexible duct connectors.
2. Comply with requirements in Section 230548 "Vibration and Seismic Controls for HVAC" and Section 230548.13 "Vibration Controls for HVAC" for vibration isolation and seismic-control] devices.

H. Install units with clearances for service and maintenance.

I. Label fans according to requirements specified in Section 230553 "Identification for HVAC Piping and Equipment."

3.2 CONNECTIONS

A. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Section 233300 "Air Duct Accessories."

B. Install ducts adjacent to fans to allow service and maintenance.

C. Install piping from scroll drain connection, with trap with seal equal to 1.5 times specified static pressure, to nearest floor drain with pipe sizes matching the drain connection.

3.3 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform the following tests and inspections with the assistance of a factoryauthorized service representative:

1. Verify that shipping, blocking, and bracing are removed.
2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
3. Verify that cleaning and adjusting are complete.
4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
5. Adjust belt tension.
6. Adjust damper linkages for proper damper operation.
7. Verify lubrication for bearings and other moving parts.
8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
9. See Section 230593 "Testing, Adjusting, and Balancing For HVAC" for testing, adjusting, and balancing procedures.
10. Remove and replace malfunctioning units and retest as specified above.

D. Test and adjust controls and safeties. Controls and equipment will be considered defective if they do not pass tests and inspections. E. Prepare test and inspection reports.

3.4 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain centrifugal fans.

END OF SECTION

SECTION 233600
AIR TERMINAL UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
1. Shutoff, single-duct air terminal units.
2. Exhaust single-duct terminal units.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of air terminal unit.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for air terminal units.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories. B. Shop Drawings: For air terminal units.

1. Include plans, elevations, sections, and mounting details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Hangers and supports, including methods for duct and building attachment, seismic restraints, and vibration isolation.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Ceiling suspension assembly members.
2. Size and location of initial access modules for acoustic tile.
3. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.

B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air terminal units to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

    a. Instructions for resetting minimum and maximum air volumes.
    b. Instructions for adjusting software set points.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."

C. ASHRAE Compliance: Applicable requirements in ASHRAE/IES 90.1, "Section 6 - Heating, Ventilating, and Air Conditioning."

2.2 SHUTOFF, SINGLE-DUCT AIR TERMINAL UNITS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. Anemostat Products; a Mestek Company.
2. Carnes.
3. Environmental Technologies, Inc.
4. Krueger.
5. METALAIRE, Inc.
6. Nailor Industries Inc.
7. Phoenix Controls Corporation.
8. Price Industries.
9. Titus.
10. Trane; a business of American Standard Companies.

B. Configuration: Volume-damper assembly inside unit casing with control components inside a protective metal shroud.

C. Casing: 0.040-inch- or 0.034-inch- thick galvanized steel, single wall.

1. Casing Liner: Comply with requirements in "Casing Liner" Article for flexible elastomeric duct liner, Hospital grade.
2. Air Inlet: Round stub connection or S-slip and drive connections for duct attachment.
3. Air Outlet: S-slip and drive connections**,** size matching inlet size.
4. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket.
5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

D. Regulator Assembly: System-air-powered bellows section incorporating polypropylene bellows for volume regulation and thermostatic control. Bellows shall operate at temperatures from zero to 140 deg F, shall be impervious to moisture and fungus, shall be suitable for 10-inch wg static pressure, and shall be factory tested for leaks.

E. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.

1. Maximum Damper Leakage: AHRI 880 rated, 2 percent of nominal airflow at 3-inch wg or 6-inch wg inlet static pressure.
2. Damper Position: Normally open or closed.

F. Attenuator Section: 0.034-inch or 0.032-inch aluminum sheet.

1. Attenuator Section Liner: Comply with requirements in "Casing Liner" Article for flexible elastomeric duct liner Hospital grade.
2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

G. Multioutlet Attenuator Section: With two, three or four 6-inch- or 8-inch- diameter collars, each with locking butterfly balancing damper.

H. Hydronic Heating Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch, and rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 220 deg F. Include manual air vent and drain valve.

I. Control devices shall be compatible with temperature controls system specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."

1. Electric Damper Actuator: 24 V, powered open, spring or capacitous return.
2. Electric Thermostat: Wall-mounted electronic type with clock display, temperature display in Fahrenheit and Celsius, and space temperature set point.
3. Electronic Velocity Controller: Factory calibrated and field adjustable to minimum and maximum air volumes; shall maintain constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-

pressure variations up to 4-inch wg; and shall have a multipoint velocity sensor at air inlet.

4. Terminal Unit Controller: Pressure-independent, variable-air-volume (VAV) controller with electronic airflow transducer with multipoint velocity sensor at air inlet, factory calibrated to minimum and maximum air volumes, and having the following features:

   a. Occupied and unoccupied operating mode.
   b. Remote reset of airflow or temperature set points.
   c. Adjusting and monitoring with portable terminal.
   d. Communication with temperature-control system specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."

5. Room Sensor: Wall mounted with temperature set-point adjustment and

access for connection of portable operator terminal. J. Controls:

1. Suitable for operation with duct pressures between 0.25- and 3.0-inch wg inlet static pressure.
2. System-powered, wall-mounted thermostat. K. Control

Sequences:

1. Occupied:

   a. In a call for cooling, airflow will increase as the damper opens towards maximum setting to satisfy set point.
   b. In a call for less cooling, airflow will decrease as the damper closes towards minimum setting to satisfy set point.

2. Unoccupied:

   a. Damper closes to minimum maximum setting.

2.3 PRESSURE CONTROL TERMINAL UNITS

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

1. Anemostat Products; a Mestek Company.
2. Carnes.
3. Krueger.
4. METALAIRE, Inc.
5. Nailor Industries Inc.
6. Price Industries.
7. Titus.
8. Trane; a business of American Standard Companies.
9. Tuttle & Bailey.

B. Configuration: Volume damper assembly inside unit casing with control components inside a protective metal shroud.

C. Casing: 0.040-inch- or 0.034-inch- thick galvanized steel, single wall.

1. Casing Liner: Comply with requirements in "Casing Liner" Article for flexible elastomeric duct liner, Hospital grade.
2. Air Inlet: Round stub connection for duct attachment.
3. Air Outlet: S-slip and drive connections.
4. Access: Removable panels for access to diverting damper and other parts requiring service, adjustment, or maintenance; with airtight gasket.
5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

D. Diverter Assembly: Galvanized-steel gate, with polyethylene linear bearings or Aluminum blade, with nylon-fitted pivot points.

E. Multioutlet Attenuator Section: With two 6-inch- or [8-inch- or 10-inch- diameter collars, each with locking butterfly balancing damper.

1. Attenuator Section Liner: Comply with requirements in "Casing Liner" Article for flexible elastomeric, Hospital grade duct liner.

F. Direct Digital Controls: Single-package unitary controller and actuator specified in Section 230923 "Direct Digital Control (DDC) System for HVAC." G.

Control Sequence:

1. Under the control of a static pressure sensor, damper opens or closes to maintain static pressure downstream branch duct.

H. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Anemostat Products; a Mestek Company.
2. Carnes.
3. Krueger.
4. METALAIRE, Inc.
5. Nailor Industries Inc.
6. Price Industries.
7. Titus.
8. Trane; a business of American Standard Companies.
9. Tuttle & Bailey.

I. Configuration: Volume-damper assembly inside unit casing with control components inside a protective metal shroud.

J. Casing: 0.040-inch- or 0.034-inch- thick galvanized steel, single wall. Casing includes removable aluminum linear grille and plenum.

1. Air Inlet: Round stub connection or S-slip and drive connections for duct attachment.
2. Air Outlet: S-slip and drive connections, size matching inlet size.
3. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket.
4. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

K. Regulator Assembly: System-air-powered bellows section incorporating polypropylene bellows for volume regulation and thermostatic control. Bellows shall operate at temperatures from zero to 140 deg F, shall be impervious to moisture and fungus, shall be suitable for 10-inch wg static pressure, and shall be factory tested for leaks.

L. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.

1. Maximum Damper Leakage: AHRI 880 rated, 2 percent of nominal airflow at 3-inch wg or 6-inch wg inlet static pressure.
2. Damper Position: Normally open or closed.

M. Attenuator Section: 0.034-inch galvanized steel or 0.032-inch aluminum sheet.

1. Casing Liner: Comply with requirements in "Casing Liner" Article for flexible elastomeric, Hospital grade duct liner.

N. Multioutlet Attenuator Section: With two 6-inch- or 8-inch- diameter collars, each with locking butterfly balancing damper.

1. Attenuator Section Liner: Comply with requirements in "Casing Liner" Article for flexible elastomeric, Hospital grade duct liner.

O. Direct Digital Controls: Single-package unitary controller and actuator specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."

P. Direct Digital Controls: Bidirectional damper operators and microprocessor-based controller and room sensor. Control devices shall be compatible with temperature controls specified in Section 230923 "Direct Digital Control (DDC) System for HVAC" and shall have the following features:

1. Damper Actuator: 24 V, powered open, spring or capacitous return.
2. Terminal Unit Controller: Pressure-independent, VAV controller with electronic airflow transducer with multipoint velocity sensor at air inlet, factory calibrated to minimum and maximum air volumes, and having the following features:

   a. Occupied and unoccupied operating mode.
   b. Remote reset of airflow or temperature set points.
   c. Adjusting and monitoring with portable terminal.

d. Communication with temperature-control system specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."

3. Pressure Sensor: Duct mounted with pressure set-point adjustment and access for connection of portable operator terminal.

Q. Controls:

1. Suitable for operation with duct pressures between 0.25- and 3.0-inch wg inlet static pressure.
2. System-powered, wall-mounted thermostat. R. Control

Sequence:

1. Damper blade opens or closes to maintain differential pressure set point in response to upstream and downstream differential pressure sensors.

2.4 CASING LINER

A. Casing Liner: Fibrous-glass duct liner, complying with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."

1. Minimum Thickness: 1 inch.

a. Maximum Thermal Conductivity:

1) Type I, Flexible: 0.27 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.
2) Type II, Rigid: [0.23 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.

2. Antimicrobial Erosion-Resistant Coating: Apply to the surface of the liner that will form the interior surface of the duct to act as a moisture repellent and erosion-resistant coating. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
3. Solvent or Water-Based Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C 916.

B. Casing Liner: Flexible elastomeric duct liner fabricated of preformed, cellular, closed-cell, sheet materials complying with ASTM C 534, Type II, Grade 1; and with NFPA 90A or NFPA 90B.

1. Minimum Thickness: 3/4 inch.
2. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
3. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.

2.5 SOURCE QUALITY CONTROL

A. Factory Tests: Test assembled air terminal units according to AHRI 880.

1. Label each air terminal unit with plan number, nominal airflow, maximum and minimum factory-set airflows, coil type, and AHRI certification seal.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 5, "Hangers and Supports" and with Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structuralsteel fasteners appropriate for construction materials to which hangers are being attached.

1. Where practical, install concrete inserts before placing concrete.
2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes and for slabs more than 4 inches thick.
4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes and for slabs less than 4 inches thick.
5. Do not use powder-actuated concrete fasteners for seismic restraints. C.

Hangers Exposed to View: Threaded rod and angle or channel supports.

D. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.2 SEISMIC-RESTRAINT-DEVICE INSTALLATION

A. Install hangers and braces designed to support the air terminal units and to restrain against seismic forces required by applicable building codes. Comply with SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems, " ASCE/SEI 7. Comply with requirements for seismic-restraint devices in Section 230548 "Vibration and Seismic Controls for HVAC."

B. Select seismic-restraint devices with capacities adequate to carry present and future static and seismic loads.

C. Install cables so they do not bend across edges of adjacent equipment or building structure.

D. Install cable restraints on air terminal units that are suspended with vibration isolators.

E. Install seismic-restraint devices using methods approved by an evaluation service member of the ICC Evaluation Service, the Office of Statewide Health Planning and Development for the State of California, an agency acceptable to authorities having jurisdiction.

F. Attachment to Structure: If specific attachment is not indicated, anchor bracing and restraints to structure, to flanges of beams, to upper truss chords of bar joists, or to concrete members.

G. Drilling for and Setting Anchors:

1. Identify position of reinforcing steel and other embedded items before drilling holes for anchors. Do not damage existing reinforcement or embedded items during drilling. Notify Architect if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Install heavy-duty sleeve anchors with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Set anchors to manufacturer's recommended torque, using a torque wrench.
5. Install zinc-coated steel anchors for interior applications and stainless-steel anchors for applications exposed to weather.

3.3 TERMINAL UNIT INSTALLATION

A. Install air terminal units according to NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems."

B. Install air terminal units level and plumb. Maintain sufficient clearance for normal service and maintenance.

C. Install wall-mounted thermostats.

3.4 CONNECTIONS

A. Where installing piping adjacent to air terminal unit, allow space for service and maintenance.

B. Hot-Water Piping: Comply with requirements in Section 232113 "Hydronic Piping" and Section 232116 Hydronic Piping Specialties," and connect heating coils to supply with shutoff valve, strainer, control valve, and union or flange; and to return with balancing valve and union or flange.

C. Comply with requirements in Section 233113 "Metal Ducts for connecting ducts to air terminal units.

3.5 IDENTIFICATION

A. Label each air terminal unit with plan number, nominal airflow, and maximum and minimum factory-set airflows. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for equipment labels and warning signs and labels.

3.6 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform the following tests and inspections:

1. After installing air terminal units and after electrical circuitry has been energized, test for compliance with requirements.
2. Leak Test: After installation, fill water coils and test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Air terminal unit will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.7 STARTUP SERVICE

A. Perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Verify that inlet duct connections are as recommended by air terminal unit manufacturer to achieve proper performance.
3. Verify that controls and control enclosure are accessible.
4. Verify that control connections are complete.
5. Verify that nameplate and identification tag are visible.
6. Verify that controls respond to inputs as specified.

3.8 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain air terminal units.

END OF SECTION

SECTION 233713
DIFFUSERS, REGISTERS, AND GRILLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Rectangular and square ceiling diffusers.
2. Linear slot diffusers.
3. Ceiling-integral continuous diffusers.
4. Adjustable bar registers and grilles.
5. Security registers and grilles.
6. Fixed face registers and grilles.
7. Linear bar grilles. B. Related Sections:

1. Division 08 for fixed and adjustable louvers and wall vents, whether or not they are connected to ducts.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated, include the following:

1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
2. Diffuser, Register, and Grille Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

B. Samples for Initial Selection: For diffusers, registers, and grilles with factoryapplied color finishes.

C. Samples for Verification: For diffusers, registers, and grilles, in manufacturer's standard sizes to verify color selected.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:

1. Ceiling suspension assembly members.
2. Method of attaching hangers to building structure.

3. Size and location of initial access modules for acoustical tile.
4. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
5. Duct access panels.

B. Source quality-control reports.

PART 2 - PRODUCTS

2.1 CEILING DIFFUSERS

A. Round Ceiling Diffuser

1. Manufacturers: available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
   a. Anemostat Products; a Mestek company.
   b. Carnes.
   c. Hart & Cooley Inc.
   d. METALAIRE, Inc.
   e. Nailor Industries Inc.
   f. Price Industries.
   g. Titus.
   h. Tuttle & Bailey.
2. Devices shall be specifically designed for variable-air-volume flows.
3. Material: Steel or Aluminum.
4. Finish: Baked enamel, white, or Baked enamel, color selected by Architect or Anodized aluminum.
5. Face Style: Four, Three or Two cone.
6. Mounting: Duct connection.
7. Pattern: Fully adjustable or Two-position horizontal.
8. Dampers: Radial opposed blade, Butterfly or Combination damper and grid.
9. Accessories:
   a. Equalizing grid.
   b. Plaster ring.
   c. Safety chain.
   d. Wire guard.
   e. Sectorizing baffles.
   f. Operating rod extension.

B. Rectangular and Square Ceiling Diffusers.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. A-J Manufacturing Co., Inc.
    b. Anemostat Products; a Mestek company.
    c. Carnes.
    d. Hart & Cooley Inc.
    e. Krueger.
    f. METALAIRE, Inc.
    g. Nailor Industries Inc.
    h. Price Industries.
    i. Titus.
    j. Tuttle & Bailey.

2. Devices shall be specifically designed for variable-air-volume flows.
3. Material: Steel or Aluminum.
4. Finish: Baked enamel, white, Baked enamel, color selected by Architect or Anodized aluminum.
5. Face Size: 24 by 24 inches, 20 by 20 inches, 12 by 12 inches.
6. Face Style: Three cone, Four cone, Plaque.
7. Mounting: Surface, T-bar, Snap in, Spline, Mounting panel.
8. Pattern: Fixed, Two position, Adjustable.
9. Dampers: Radial opposed blade, Butterfly, Combination damper and grid.
10. Accessories:

    a. Equalizing grid.
    b. Plaster ring.
    c. Safety chain.
    d. Wire guard.
    e. Sectorizing baffles.
    f. Operating rod extension.

2.2 CEILING LINEAR SLOT OUTLETS

A. Linear Slot Diffuser.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. Air Research Diffuser Products, Inc.

    b. Anemostat Products; a Mestek company.

    c. Carnes.

    d. Hart & Cooley Inc.

    e. Krueger.

    f. METALAIRE, Inc.

    g. Nailor Industries Inc.

    h. Price Industries.

    i. Titus.

    j. Tuttle & Bailey.

2. Devices shall be specifically designed for variable-air-volume flows.

3. Material - Shell: Steel, Aluminum, insulated or non-insulated.

4. Material - Pattern Controller and Tees: Aluminum.

5. Finish - Face and Shell: Baked enamel, black.

6. Finish - Pattern Controller: Baked enamel, black.

7. Finish - Tees: Baked enamel, white, Baked enamel, color selected by Architect.

8. Slot Width: 1/2 inch, 3/4 inch, 1 inch, -1/2 inches.

9. Number of Slots: One, Two, Three, Four.

10. Length: Refer to drawings].

11. Accessories: Plaster frame, T-bar slot, Center notch, T-bar on inlet side, Tbar on both sides, T-bar clip on one side, T-bar clips on both sides. B. Ceiling-Integral Continuous Diffuser.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. Air Research Diffuser Products, Inc.

    b. Anemostat Products; a Mestek company.

    c. Carnes.

    d. Hart & Cooley Inc.

    e. Krueger.

    f. METALAIRE, Inc.

g. Nailor Industries Inc.

h. Price Industries.

i. Titus.

j. Tuttle & Bailey.

2. Slot Width: 1 inch, -1/2 inches, 2 inches, 1-1/2 inches, 3 inches.

3. Straight and curved sections as required to accommodate layout.

4. Mitered tees and corners.

5. Pattern Controllers: 24 inches o.c.

6. Material: Aluminum, extruded, heavy wall.

7. Finishes:

a. Exterior: Standard white.

b. Interior: Standard black.

8. Throw: Standard, High.

9. Mounting: Ceiling, Sidewall.

10. Plenum: Noninsulated, Insulated.

11. Other Features:

a. Painted interior.

b. Blank-offs.

2.3 REGISTERS AND GRILLES

A. Adjustable Bar Register:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. A-J Manufacturing Co., Inc.

b. Anemostat Products; a Mestek company.

c. Carnes.

d. Dayus Register & Grille Inc.

e. Hart & Cooley Inc.

f. Krueger.

g. METALAIRE, Inc.

h. Nailor Industries Inc.

i. Price Industries.

j. Titus.

k. Tuttle & Bailey.

2. Material: Steel, Aluminum, Stainless steel.

3. Finish: Baked enamel, white, Baked enamel, color selected by Architect.

4. Face Blade Arrangement: Horizontal, Vertical spaced 3 inches, 1-1/2 inches, 3/4 inch, 1/2 inch apart.

5. Core Construction: Integral, Removable.

6. Rear-Blade Arrangement: Horizontal, Vertical spaced 3/4 inch, 1/2 inch apart.

7. Frame: 1-1/4 inches, 1 inch wide.

8. Mounting Frame: Filter.

9. Mounting: Countersunk screw, Concealed, Lay in.

10. Damper Type: Adjustable opposed blade, NRTL listed, opposed blade, spring closing, and with fusible link for 160 deg F.

11. Accessories:

a. Front, Rear-blade gang operator.

b. Filter.

B. Adjustable Bar Grille:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. A-J Manufacturing Co., Inc.

b. Anemostat Products; a Mestek company.

c. Carnes.

d. Dayus Register & Grille Inc.

e. Hart & Cooley Inc.

f. Krueger.

g. METALAIRE, Inc.

h. Nailor Industries Inc.

i. Price Industries.

j. Titus.

k. Tuttle & Bailey.

2. Material: Steel, Aluminum, Stainless steel.

3. Finish: Baked enamel, white, Baked enamel, color selected by Architect.

4. Face Blade Arrangement: Horizontal, Vertical spaced 3 inches, 1-1/2 inches, 3/4 inch, 1/2 inch apart.

5. Core Construction: Integral, Removable.
6. Rear-Blade Arrangement: Horizontal, Vertical spaced 3/4 inch, 1/2 inch apart.
7. Frame: 1-1/4 inches, 1 inch wide.
8. Mounting Frame: Filter.
9. Mounting: Countersunk screw, Concealed, Lay in. C. Linear Bar Grille.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
    a. A-J Manufacturing Co., Inc.
    b. Anemostat Products; a Mestek company.
    c. Carnes.
    d. Dayus Register & Grille Inc.
    e. Hart & Cooley Inc.
    f. Krueger.
    g. Nailor Industries Inc.
    h. Price Industries.
    i. Titus.
    j. Tuttle & Bailey.
2. Material: Steel, Aluminum.
3. Finish: Baked enamel, white, Baked enamel, color selected by Architect.
4. Face Arrangement: 1/2-by-1/2-by-1/2-inch grid or Perforated core.
5. Distribution plenum.
    a. Internal insulation.
    b. Inlet damper.
6. Frame: 1-1/4 inches or 1 inch wide.
7. Mounting Frame: Filter.
8. Mounting: Countersunk screw, Concealed or Lay in.
9. Damper Type: Adjustable opposed blade.

2.4 SOURCE QUALITY CONTROL

A. Verification of Performance: Rate diffusers, registers, and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas where diffusers, registers, and grilles are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.

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

3.2 INSTALLATION

A. Install diffusers, registers, and grilles level and plumb.

B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

C. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.3 ADJUSTING

A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION

SECTION 238123
COMPUTER-ROOM AIR-CONDITIONERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Floor-mounted computer-room air conditioners, 6 tons and larger.
2. Floor-mounted computer-room air conditioners, 5 tons and smaller.
3. Ceiling-mounted computer-room air conditioners.
4. Console computer-room air conditioners.

1.3 DEFINITION

A. BAS: Building automation system.

1.4 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Computer-room air conditioners shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. LEED Submittals:

1. Product Data for Credit EA 4: Documentation indicating that equipment and refrigerants comply.
2. Product Data for Prerequisite IEQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."

C. Shop Drawings: For computer-room air conditioners. Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

2. Wiring Diagrams: For power, signal, and control wiring.

D. Color Samples: For unit cabinet, discharge grille, and exterior louver and for each color and texture specified.

1.6 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, elevations, and other details, drawn to scale, using input from Installers of the items involved.

B. Seismic Qualification Certificates: For computer-room air conditioners, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements. C. Field quality-control reports.

D. Warranty: Sample of special warranty.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For computer-room air conditioners to include in emergency, operation, and maintenance manuals.

1.8 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fan Belts: **One** set(s) for each belt-driven fan.
2. Filters: **One** set(s) of filters for each unit.

1.9 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASHRAE Compliance:

1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."
2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - "Ventilation Rate Procedures," and Section 7 - "Construction and Startup."

C. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1.

D. ASME Compliance: Fabricate and label water-cooled condenser shell to comply with ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," Division 1.

1.10 COORDINATION

A. Coordinate layout and installation of computer-room air conditioners and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

B. Coordinate installation of computer-room air conditioners with computer-room access flooring Installer.

C. Coordinate sizes and locations of concrete bases with actual equipment provided.

D. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

1.11 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of computer-room air conditioners that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Compressors: Manufacturer's standard, but not less than **five** years from date of Substantial Completion.
2. Warranty Period for Humidifiers: Manufacturer's standard, but not less than **three** years from date of Substantial Completion.
3. Warranty Period for Control Boards: Manufacturer's standard, but not less than **three** years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 FLOOR-MOUNTED UNITS 6 TONS AND LARGER

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

1. Airflow Company; a division of The McClain Company, Inc.
2. Carrier Corporation; a United Technologies company.
3. Compu-Aire, Inc.
4. Data Aire Inc.
5. Koldwave, Inc.; a Mestek company.
6. Liebert Corporation.
7. McQuay International.
8. Stulz-ATS.

9. Trane; a business of American Standard Companies.

B. Description: Packaged, factory assembled, prewired, and pre-piped; consisting of cabinet, fans, filters, humidifier, and controls.

C. Cabinet and Frame: Welded steel, braced for rigidity, and supporting compressors and other mechanical equipment and fittings.

1. Doors and Access Panels: Galvanized steel with polyurethane gaskets, hinges, and concealed fastening devices.
2. Insulation: Thermally and acoustically insulate cabinet interior with 1-inch-thick duct liner.
3. Finish of Interior Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
4. Finish of Exterior Surfaces: Baked-on, textured vinyl enamel; color as selected from manufacturer's standard colors.
5. Floor Stand: Welded tubular steel, 6” high, with adjustable legs and vibration isolation pads. D. Supply-Air Fan(s):

1. Double-inlet, forward-curved centrifugal fan(s); statically and dynamically balanced.
2. Drive: V-belt, with steel shaft with self-aligning ball bearings and cast-iron or steel sheaves, variable- and adjustable-pitch motor sheave, minimum of two matched belts, with drive rated at a minimum of two times the nameplate rating of motor.

E. Refrigeration System:

1. Compressors: Hermetic scroll; with oil strainer, internal motor overload protection, resilient suspension system, crankcase heater, manual-reset highpressure switch, and pump-down low-pressure switch.
2. Refrigeration Circuits: Two; each with hot-gas mufflers, thermal-expansion valve with external equalizer, liquid-line solenoid valve, liquid-line filter-dryer, sight glass with moisture indicator, service shutoff valves, charging valves, and charge of refrigerant.
3. Refrigerant: R-410A.
4. Refrigerant Evaporator Coil: Alternate-row or split-face-circuit, directexpansion coil of seamless copper tubes expanded into aluminum fins.

   a. Mount coil assembly over stainless-steel drain pan complying with ASHRAE 62.1 and having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir.

5. Remote Air-Cooled Refrigerant Condenser: Corrosion-resistant cabinet, copper-tube aluminum-fin coils arranged for two circuits, multiple direct-drive propeller fans with permanently lubricated ball bearings, and single-phase motors with internal overload protection and integral electric control

panel **and disconnect switch. Control capacity by modulating fan speeds.**

F. Remote, Air-Cooled, Glycol-Solution Cooler: Corrosion-resistant cabinet, coppertube aluminum-fin coil, multiple direct-drive propeller fans with fan guards, and single-phase motors with internal overload protection and integral electric control panel. Control capacity by cycling fans.

1. Disconnect Switch: Nonautomatic, molded-case circuit breaker with handle accessible when panel is closed and capable of preventing access until switched to off position.

G. Electric-Resistance Heating Coil: Enclosed finned-tube electric elements arranged for minimum of three stages, with thermal safety switches, manual-reset overload protection, and branch-circuit overcurrent protection.

H. Extended-Surface, Disposable, Panel Filter: Pleated, lofted, nonwoven, reinforced cotton fabric; supported and bonded to welded-wire grid; enclosed in cardboard frame with 2-inch- thick, disposable, glass-fiber pre-filter.

I. Infrared Humidifier: High-intensity quartz lamps mounted above stainless-steel evaporator pan, serviceable without disconnecting water, drain, or electrical connections; prepiped and using condensate water from cooling coils with stainlesssteel or brass float-valve mechanism; located in bypass airstream; with flush-cycle timer and solenoid drain valve.

J. Integral Electrical Controls: Unit-mounted electrical enclosure with piano-hinged door, grounding lug, combination magnetic starters with overload relays, circuit breakers and cover interlock, and fusible control-circuit transformer.

K. Disconnect Switch: Nonautomatic, molded-case circuit breaker with handle accessible when panel is closed and capable of preventing access until switched to off position.

L. Electronic-Control System: Solid state, with start button, stop button, temporary loss of power indicator, manual-reset circuit breakers, temperature control, humidity control, and monitor panel.

1. Monitor Panel: Backlighted, with no visible indicator lights until operating function is activated; indicators include cooling, humidification, loss of airflow, change filters, high temperature, low temperature, high humidity, low humidity, high head pressure (each compressor), and low suction pressure (each compressor).
2. Temperature- and Humidity-Control Modules: Solid state, plug-in; with adjustable set point, push-to-test calibration check button, and built-in visual indicators to show mode of operation.
3. Location: Behind hinged door in front of unit; isolated from conditioned airstream to allow service while system is operating.

M. Microprocessor-Control System: Continuously monitors operation of process cooling system; continuously displays room temperature and room relative humidity; sounds alarm on system malfunction and simultaneously displays problem. If more than one malfunction occurs, system displays fault in sequence

with room temperature and continues to display fault when malfunction is cleared until system is reset.

1. Malfunctions:

   a. Power loss.
   b. Loss of airflow.
   c. Clogged air filter.
   d. High room temperature.
   e. Low room temperature.
   f. High humidity.
   g. Low humidity.
   h. Smoke/fire.
   i. Water under floor.
   j. Supply fan overload.
   k. Compressor No. 1 - Overload.
   l. Compressor No. 1 - Low Pressure.
   m. Compressor No. 1 - High Pressure.
   n. Compressor No. 2 - Overload.
   o. Compressor No. 2 - Low Pressure.
   p. Compressor No. 2 - High Pressure.

2. Digital Display:

   a. Control power on.
   b. Humidifying.
   c. Dehumidifying.
   d. Compressor No. 1 - Operating.
   e. Compressor No. 2 - Operating.
   f. Heat operating.
   g. Economy cooling.

3. Push buttons shall stop and start process cooling system, silence audible alarm, test indicators, and display room's relative humidity.

4. BAS Interface: Factory-installed hardware and software to enable the BAS to monitor, control, and display unit status and alarms.

   a. Hardwired Points:

      1) Monitoring: On-off status, common trouble alarm, space temperature and space relative humidity.

      2) Control: On-off operation, space temperature set-point adjustment, space relative humidity set-point adjustment.

   b. ASHRAE 135 (BACnet) communication interface with the BAS shall enable the BAS operator to remotely control and monitor the unit from an operator workstation. Control features and monitoring points displayed locally at unit control panel shall be available through the BAS.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for hydronic piping systems to verify actual locations of piping connections before equipment installation.

C. Examine walls, floors, and roofs for suitable conditions where computer-room air conditioners will be installed.

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

3.2 INSTALLATION

A. Install computer-room air conditioners level and plumb, maintaining manufacturer's recommended clearances. Install according to ARI Guideline B.

B. Computer-Room Air-Conditioner Mounting: Install using elastomeric pads. Comply with requirements for vibration isolation devices specified in Division 23.

   1. Minimum Deflection: 1/4 inch.

C. Air-Cooled Refrigerant Condenser Mounting: Install using elastomeric pads. Comply with requirements for vibration isolation devices specified in Division 23.

   1. Minimum Deflection: 1/4 inch.

D. Remote, Air-Cooled, Glycol-Solution Cooler Mounting: Install using elastomeric pads. Comply with requirements for vibration isolation devices specified in Division 23.

   1. Minimum Deflection: 1/4 inch.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other heating, ventilating, and airconditioning Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to machine to allow service and maintenance.

C. Water and Drainage Connections: Comply with applicable requirements in Division 22. Provide adequate connections for water-cooled units, condensate drain, and humidifier flushing system.

D. Refrigerant Piping: Comply with applicable requirements in Division 23. Provide shutoff valves and piping.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing. C. Tests and Inspections:

1. Inspect for and remove shipping bolts, blocks, and tie-down straps.
2. After installing computer-room air conditioners and after electrical circuitry has been energized, test for compliance with requirements.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Computer-room air conditioners will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

F. After startup service and performance test, change filters and flush humidifier.

3.5 ADJUSTING

A. Adjust initial temperature and humidity set points.

B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain computer-room air conditioners.

END OF SECTION

SECTION 238216 AIR COILS

PART 1- GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes hydronic heating and cooling air coils.
   1. Hot Water Coil
   2. Chilled water Coil
   3. Steam Coil
   4. Refrigerant

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

   1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each air coil.
   2. Include rated capacities, operating characteristics, and pressure drops for each air coil.
   3. Shop Drawings: Diagram power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which coil location and ceiling-mounted access panels are shown and coordinated with each other.

B. Field quality-control test reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air coils to include in operation and maintenance manuals.

1.6 DESCRIPTION

A. ASHRAE Compliance: Comply with applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

B. ASHRAE Compliance: Comply with applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup." C.

Comply with ASHRAE 33 for methods of testing cooling and heating coils.

D. 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 market to intend use.

E. Comply with ASHRAE 15 for refrigeration system safety.

1.7 PROJECT CONDITIONS

a. Altitude above Mean Sea Level

PART 2 - PRODUCTS

2.1 WATER COILS

A. Manufacturers: subject to compliance with requirements, provide products by one of the following:
   a. Aerofin Corporation
   b. Carrier Corporation
   c. Coil Company LLC
   d. Dunham-Bush, Inc
   e. Heatcraft Refrigeration Products LLC; heat Transfer Division
   f. Precision Coils
   g. Super Radiator Coils
   h. Trane
   i. USA Coil & Air

B. Performance Ratings: Tested and rated according to AHRI 410 and ASHRAE 33.

C. Minimum Working-Pressure/Temperature Ratings: 200 psig at 325 deg F.

D. Source Quality Control: Factory tested to 300 psig.

E. Tubes: ASTM B 743 copper, minimum 0.020 inch, 0.035 inch or 0.049 inch thick.

F. Fins: Aluminum or Copper, minimum 0.006 inch or 0.010 inch thick.

G. Headers: Cast iron with drain and air vent tappings, Cast iron with cleaning plugs and drain and air vent tappings, Seamless copper tube with brazed joints, prime coated, Steel with brazed joints, prime coated.

H. Frames: Galvanized-steel channel frame, minimum 0.052 inch, 0.064 inch or 0.079 inch thick for slip-in or flanged mounting.

I. Frames: ASTM A 666, Type 304 or Type 316 stainless steel, minimum 0.0625 inch thick for slip-in or flanged mounting.

J. Hot-Water Coil, Face-and-Bypass Dampers: Alternating arrangement of coil segments and dampers.

1. Coil Configuration: Horizontal or Vertical tubes.
2. Dampers: Extruded-aluminum or Galvanized-steel blades with edge and end seals; full-length drive rod and mount for actuator in or outside the airstream. K. Hot-Water Coil Capacities and Characteristics: Refer to Schedules.

L. Chilled-Water Coil Capacities and Characteristics: Refer to Schedules.

2.2 REFRIGERANT COILS

A. Manufacturers: subject to compliance with requirements, provide products by one of the following:
   a. Aerofin Corporation
   b. Carrier Corporation
   c. Coil Company LLC
   d. Dunham-Bush, Inc
   e. Heatcraft Refrigeration Products LLC; heat Transfer Division
   f. Lennox Industries Inc
   g. Super Radiator Coils
   h. Trane
   i. USA Coil & Air

B. Performance Ratings: Tested and rated according to AHRI 410 and ASHRAE 33.

C. Minimum Working-Pressure Rating: 300 psig.

D. Source Quality Control: Factory tested to 450 psig.

E. Tubes: ASTM B 743 copper, minimum 0.020 inch, 0.035 inch or 0.049 inch thick.

F. Fins: Aluminum or Copper, minimum 0.006 inch or 0.010 inch thick.

G. Suction and Distributor Piping: ASTM B 88, Type L copper tube with brazed joints.

H. Frames: Galvanized-steel channel frame, minimum 0.052 inch, 0.064 inch or 0.079 inch thick for slip-in or flanged mounting.

I. Frames: ASTM A 666, Type 304 or Type 316 stainless steel, minimum 0.0625 inch thick for slip-in or flanged mounting.

J. Capacities and Characteristics: Refer to Schedules.

2.3 STEAM COILS

A. Manufacturers: subject to compliance with requirements, provide products by one of the following:
   a. Aerofin Corporation
   b. Carrier Corporation
   c. Coil Company LLC
   d. Dunham-Bush, Inc
   e. Heatcraft Refrigeration Products LLC; heat Transfer Division
   f. Super Radiator Coils
   g. Trane
   h. USA Coil & Air

B. Performance Ratings: Tested and rated according to AHRI 410 and ASHRAE 33.

C. Minimum Working-Pressure/Temperature Ratings: 100 psig at 400 deg F.

D. Source Quality Control: Factory tested to 300 psig.

E. Tubes: ASTM B 743 copper, minimum 0.025 inch, 0.035 inch or 0.049 inch thick.

F. Fins: Aluminum or Copper, minimum 0.006 inch or 0.010 inch thick.

G. Headers: Cast iron with drain and air vent tappings, Cast iron with cleaning plugs, and drain and air vent tappings, Seamless copper tube with brazed joints, prime coated, Steel with brazed joints, prime coated. H. Tube Type: Single or distributing as indicated.

I. Frames: Galvanized-steel channel frame, minimum [0.052 inch (1.3 mm)] [0.064 inch (1.6 mm)] [0.079 inch (2.0 mm)] thick for [slip-in] [flanged] mounting.

J. Frames: ASTM A 666, Type 304 or Type 316 stainless steel, minimum 0.0625 inch thick for [slip-in] [flanged] mounting.

K. Face-and-Bypass Dampers: Alternating arrangement of coil segments and dampers.

   1. Coil Configuration: Horizontal or Vertical tubes.
   2. Dampers: Extruded-aluminum or Galvanized-steel blades with edge and end seals; full-length drive rod and mount for actuator in or outside the airstream. L. Capacities and Characteristics: Refer to Schedules.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine ducts, plenums, and casings to receive air coils for compliance with requirements for installation tolerances and other conditions affecting coil performance.

B. Examine roughing-in for piping systems to verify actual locations of piping connections before coil installation.

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

3.2 INSTALLATION

A. Install coils level and plumb.

B. Install coils in metal ducts and casings constructed according to SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."

C. Install galvanized or stainless-steel drain pan under each cooling coil.

1. Construct drain pans with connection for drain; insulated and complying with ASHRAE 62.1.
2. Construct drain pans to extend beyond coil length and width and to connect to condensate trap and drainage.
3. Extend drain pan upstream and downstream from coil face.
4. Extend drain pan under coil headers and exposed supply piping.

D. Install moisture eliminators for cooling coils. Extend drain pan under moisture eliminator.

E. Straighten bent fins on air coils.

F. Clean coils using materials and methods recommended in writing by manufacturers, and clean inside of casings and enclosures to remove dust and debris.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to coils to allow service and maintenance.

C. Connect water piping with unions and shutoff valves to allow coils to be disconnected without draining piping. Control valves are specified in Section 230923.11 "Control Valves," and other piping specialties are specified in Section 232116 "Hydronic Piping Specialties."

D. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

E. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

F. Connect steam piping with gate valve and union and steam condensate piping with union, strainer, trap, and gate valve to allow coils to be disconnected without draining piping. Control valves are specified in Section 230923.11 "Control Valves," and other piping specialties are specified in Section 232213 "Steam and Condensate Heating Piping."

G. Connect refrigerant piping according to Section 232300 "Refrigerant Piping."

3.4 END FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factoryauthorized service representative:

1. Operational Test: After electrical circuitry has been energized, operate electric coils to confirm proper unit operation.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Prepare test and inspection reports. END OF SECTION

SECTION 238316
RADIANT-HEATING HYDRONIC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes radiant-heating piping, including:

1. PEX pipe and fittings
2. PEX-AL-PEX pipe and fittings
3. Distribution manifolds
4. Piping specialties
5. Controls

1.3 DEFINITIONS

A. CWP: Cold working pressure.

B. PEX: Crosslinked polyethylene.

C. PEX/AL/PEX: Crosslinked polyethylene/aluminum/crosslinked polyethylene.

D. PTFE: Polytetrafluoroethylene plastic.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include data for piping, fittings, manifolds, specialties, and controls; include pressure and temperature ratings, oxygen-barrier performance, fireperformance characteristics, and water-flow and pressure-drop characteristics.

B. Shop Drawings: Show piping layout and details drawn to scale, including valves, manifolds, controls, and support assemblies, and their attachments to building structure.

1. Shop Drawing Scale: 1/4 inch = 1 foot.

A.

1.5 INFORMATIONAL SUBMITTALS

Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Suspended ceiling components.
2. Structural members to which radiant-heating piping will be attached.
3. Items penetrating finished ceiling, including the following:
    a. Lighting fixtures.
    b. Air outlets and inlets.
    c. Speakers.
    d. Sprinklers.
    e. Access panels.
4. Perimeter moldings.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For radiant-heating piping valves and equipment to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 PEX PIPE AND FITTINGS

A. Manufacturers: Subject to compliance with requirements, provided products by the following:

1. FloorHeat Company (The)
2. Heat Innovations Inc
3. HeatLink Group Inc
4. Infloor radiant Floor Heating
5. IPEX Inc
6. Mr Pex Systems Inc
7. REHAU Incorporation
8. Stan/Fin Corporation
9. Uponor
10. Viega
11. Warmboard Inc
12. Watts Radiant Inc, a Watts Water Technologies company
13. Zurn industries, LLC; Zurn Pex Inc

14. Zehunder Rittiny

B. Pipe Material: PEX plastic according to ASTM F 876.

C. Oxygen Barrier: Limit oxygen diffusion through the tube to maximum 0.10 mg per cu. m/day at 104 deg F according to DIN 4726.

D. Fittings: ASTM F 1807, metal insert and copper crimp rings, ASTM F 1960, cold expansion fittings and reinforcing rings.

E. Pressure/Temperature Rating: Minimum 100 psig and 180 deg F).

2.2 PEX/AL/PEX PIPE AND FITTINGS

A. Manufacturers: Subject to compliance with requirements, provided products by the following:
1. Heat Innovations Inc
2. IPEX Inc
3. Uponor
4. Viega

B. Pipe Material: PEX plastic bonded to the inside and outside of a welded aluminum tube according to ASTM F 1281.

C. Oxygen Barrier: Limit oxygen diffusion through the pipe to maximum 0.10 mg per cu. m/day at 104 deg F according to DIN 4726.

D. Fittings: ASTM F 1974, metal insert fittings with split ring and compression nut (compression joint) or metal insert fittings with copper crimp rings (crimp joint).

E. Flame-Spread and Smoke-Developed Indices: 25 and 50 or less, respectively, tested according to ASTM E 84.

F. Pressure/Temperature Rating: Minimum 100 psig and 210 deg F.

2.3 EPDM PIPE AND FITTINGS

A. Manufacturers: Subject to compliance with requirements, provided products by the following:
1. Watts Radiant Inc, a Watts Water Technologies company **B.**

Pipe Material: Crosslinked EPDM inner and outer tubes.

C. Wall Thickness: Minimum 0.125 inch.

D. Oxygen Barrier: Ductile aluminum foil layer applied to the inner tube to limit oxygen diffusion through the pipe to maximum 0.10 mg per cu. m/day at 104 deg F according to DIN 4726.

A.
E. Reinforcing Braid: Braided-aluminum wire between the inner and outer tube.

F. Fittings: ASTM F 1807, copper with stainless-steel crimps or clamps.

G. Pressure/Temperature Rating: Minimum 100 psig and 210 deg F.

2.4 DISTRIBUTION MANIFOLDS

Manifold: Minimum NPS 1 brass, copper or stainless steel. **B.**

Main Shutoff Valves:

1. Factory installed on supply and return connections.
2. Two or Three-piece body.
3. Body: Brass or bronze.
4. Ball: Chrome-plated bronze.
5. Seals: PTFE.
6. CWP Rating: 150 psig.
7. Maximum Operating Temperature: 225 deg F. **C.** Manual Air Vents:

1. Body: Bronze.
2. Internal Parts: Nonferrous.
3. Operator: Key furnished with valve, or screwdriver bit.
4. Inlet Connection: NPS 1/2.
5. Discharge Connection: NPS 1/8.
6. CWP Rating: 150 psig.
7. Maximum Operating Temperature: 225 deg F. **D.** Balancing Valves:

1. Body: Plastic or bronze, ball or plug, or globe cartridge type.
2. Ball or Plug: Brass or stainless steel.
3. Globe Cartridge and Washer: Brass with EPDM composition washer.
4. Seat: PTFE.
5. Visual Flow Indicator: Flowmeter with visible indication in a clear plastic cap at top of valve.
6. Differential Pressure Gage Connections: Integral seals for portable meter to measure loss across calibrated orifice.
7. Handle Style: Lever or knob, with memory stop to retain set position if used for shutoff.
8. CWP Rating: Minimum 125 psig.
9. Maximum Operating Temperature: 250 deg F. **E.** Zone Control Valves:

1. Body: Plastic or bronze, ball or plug, or globe cartridge type.
2. Ball or Plug: Brass or stainless steel.
3. Globe Cartridge and Washer: Brass with EPDM composition washer.
4. Seat: PTFE.
5. Actuator: Replaceable electric motor.

6. CWP Rating: Minimum 125 psig.
7. Maximum Operating Temperature: 250 deg F. **F.** Thermometers:

1. Mount on supply and return connections.
2. Case: Dry type, metal or plastic, 2-inch diameter.
3. Element: Bourdon tube or other type of pressure element.
4. Movement: Mechanical, connecting element and pointer.
5. Dial: Satin-faced, nonreflective aluminum with permanently etched scale markings.
6. Pointer: Black metal.
7. Window: Plastic.
8. Connector: Rigid, back type.
9. Thermal System: Liquid- or mercury-filled bulb in copper-plated steel, aluminum, or brass stem.
10. Accuracy: Plus or minus 1 percent of range or plus or minus 1 scale division to maximum of 1.5 percent of range.

G. Mounting Brackets: Copper, or plastic- or copper-clad steel, where in contact with manifold.

2.5 PIPING SPECIALTIES A.

Cable Ties:

1. Fungus-inert, self-extinguishing, one-piece, self-locking, Type 6/6 nylon cable ties.
2. Minimum Width: 1/8 inch.
3. Tensile Strength: 20 lb, minimum.
4. Temperature Range: Minus 40 to plus 185 deg F. **B.** Channeled Subfloor:

1. Plywood, APA-rated subfloor panel, composed of premium, tongue-andgroove, seven-layer, Douglas fir structural subfloor panels.
2. Particleboard manufactured to comply with Federal Housing Authority standards of less than 0.3-ppm formaldehyde.
3. Clad panel with minimum 0.025-inch-thick aluminum recessed in the grooves sized to maintain contact with radiant piping. **C.** Modular Interlocking Blocks:

1. Polypropylene snap-together blocks with grooves to support piping.
2. Galvanized sheet metal or aluminum emission plates.
3. Natural mineralboard cover panel. **D.** Heat-Emission Plates:

1. Formed aluminum suitable for radiant-heating piping.
2. Minimum Thickness: 1/16 inch.
3. Slot Width: Snap fit to maintain pressure fit on tubing.

2.6 CONTROLS

Temperature-control devices and sequence of operations are specified in

A.

Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC."

B. Manufacturers: Subject to compliance with requirements, provided products by the following:

1. Danfoss
2. HeatLink Group Inc
3. Honeywell Group Inc
4. Infloor radiant Floor Heating
5. IPEX Inc
6. REHAU Incorporation
7. Stan/Fin Corporation
8. Tekmar Control Systems, Ltd
9. Uponor
10. Viega
11. Watts Radiant Inc, a Watts Water Technologies company
12. Zurn industries, LLC; Zurn Pex Inc **C.** Wall-Mounted Thermostat:

1. Minimum temperature range from 50 to 90 deg F.
2. Manually operated with on-off switch.
3. Day and night setback and clock program with minimum four periods per day.
4. Operate pumps or open zone control valves if room temperature falls below the thermostat setting, and stop pumps or close zone control valves when room temperature rises above the thermostat setting. **D.** Heated-Panel Thermostat:

1. Remote bulb unit with adjustable temperature range from 50 to 90 deg F.
2. Snap action; open-on-rise, single-pole switch with minimum current rating adequate for connected pump or zone control valve.
3. Remote bulb on capillary tube, resistance temperature device, or thermistor for directly sensing radiant-panel temperature.
4. Stop pump or close zone control valves if heated-panel thermostat setting is exceeded.
5. Corrosion-resistant, waterproof control enclosure. **E.** Precipitation and

Temperature Sensor:

1. Automatic control with manual on, automatic, and standby/reset switch.
2. Precipitation and temperature sensors shall sense the surface conditions of pavement and shall be programmed to operate pump and zone control valves as follows:

    a. Temperature Span: 34 to 44 deg F.

b. Adjustable Delay Off Span: 30 to 90 minutes.
c. Start Pump or Open Zone Control Valves: Following two-minute delay if ambient temperature is below set point and precipitation is detected.
d. Stop Pump or Close Zone Control Valves: On detection of a dry surface plus time delay.

3. Corrosion-proof and waterproof enclosure suitable for outdoor mounting, for controls and precipitation and temperature sensors.
4. Minimum 30-A contactor to start pump and open valves.
5. Precipitation sensor shall be mounted in pavement.
6. Provide relay with contacts to indicate operational status, on or off, for interface with central HVAC control-system workstation.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine surfaces and substrates to receive radiant-heating piping for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

1. Ensure that surfaces and pipes in contact with radiant-heating piping are free of burrs and sharp protrusions.
2. Ensure that surfaces and substrates are level and plumb.

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

3.2 APPLICATIONS

A. Install the following types of radiant-heating piping for the applications described:
1. Piping in Ceilings: EPDM, PEX, PEX/AL/PEX.

3.3 INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicate piping locations and arrangements if such were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop Drawings or coordination drawings.

B. Install radiant-heating piping continuous from the manifold through the heated panel and back to the manifold without piping joints in heated panels. **C.** Connect radiant piping to manifold in a reverse-return arrangement.

A.

D. Do not bend pipes in radii smaller than manufacturer's minimum bend radius dimensions.

E. Install manifolds in accessible locations, or install access panels to provide maintenance access as required in Section 083113 "Access Doors and Frames."

F. Comply with requirements in Section 232113 "Hydronic Piping" and Section 232116 Hydronic Piping Specialties" for pipes and connections to hydronic systems and for glycol-solution fill requirements.

G. Fire- and Smoke-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials according to Section 078413 "Penetration Firestopping." **H.** Piping in Ceiling:

1. Secure piping by attaching pipes to ceiling substrate using clamps or staples.
2. Space clamps or staples a maximum of 18 inches o.c. and at center of turns or bends.
3. Maintain 1-1/2-inch minimum plaster cover.
4. Maintain minimum 40-psig pressure in piping during the plaster application and continue for 24 hours during curing.

I. Revise locations and elevations from those indicated as required to suit field conditions and ensure integrity of piping and as approved by Architect.

J. After system balancing has been completed, mark balancing valves to permanently indicate final position.

K. Perform the following adjustments before operating the system:

1. Open valves to fully open position.
2. Check operation of automatic valves.
3. Set temperature controls so all zones call for full flow.
4. Purge air from piping.

L. After concrete or plaster heating panel has cured as recommended by concrete or plaster supplier, operate radiant-heating system as follows:

1. Start system heating at a maximum of 10 deg F above the ambient radiantpanel temperature and increase 10 deg F each following day until design temperature is achieved.
2. For freeze protection, operate at a minimum of 60 deg F supply-water temperature.

3.4 FIELD QUALITY CONTROL

A. Prepare radiant-heating piping for testing as follows:

1. Open all isolation valves and close bypass valves.

2. Open and verify operation of zone control valves.
3. Flush with clean water and clean strainers.

B. Perform the following tests and inspections:

1. Leak Test: After installation, charge system and test for leaks. Subject piping to hydrostatic test pressure that is not less than 1.5 times the design pressure but not more than 100 psig. Repair leaks and retest until no leaks exist.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Radiant-heating piping will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

E. Protect hydronic piping system from damage during construction.

END OF SECTION

SECTION 238413 HUMIDIFIERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following humidifiers:

1. Steam injection.

1.3 DEFINITION

A. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

1.4 ACTION SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings: Detail fabrication and installation of humidifiers. Include piping details, plans, elevations, and sections, details of components, manifolds, and attachments to other work.

1. Wiring Diagrams: Power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Detail humidifiers and adjacent equipment. Show support locations, type of support, weight on each support, required clearances, and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

1. Structural members to which humidifiers will be attached.
2. Size and location of initial access modules for acoustical tile. B.

Field quality-control test reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For humidifiers to include in operation and maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Supply one replacement electrode cylinder with each self-contained humidifier.

1.8 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with ARI 640, "Commercial and Industrial Humidifiers."

1.9 COORDINATION

A. Coordinate location and installation of humidifiers with manifolds in ducts and airhandling units or occupied space. Revise locations and elevations to suit field conditions and to ensure proper humidifier operation.

PART 2 - PRODUCTS

2.1 STEAM-INJECTION HUMIDIFIERS

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

1. Armstrong International, Inc.
2. Carel USA, LLC.
3. DRI-STEEM Humidifier Company.
4. Herrmidifier.
5. Hygromatik; Spirax Sarco, Inc.
6. Nortec Industries Inc.
7. Pure Humidifier Company.

B. Manifold: ASTM A 666, Type 304 stainless steel, steam jacketed; or insulated with 1/2-inch fiberglass and stainless-steel jacket; and extending the full width of duct or plenum with mounting brackets at ends. C. Discharge Nozzle and Dispersion Fan:

1. Steam-jacketed discharge nozzle, aluminum blade propeller fan with finger guard, and single-speed motor interlocked to operate with humidifier.
2. Fan Mounting: Above and behind discharge outlet on bracket integral to discharge outlet.

D. Steam Separator: Cast iron, ASTM A 666, Type 304 stainless steel with separate humidifier control valve. E. Humidifier Control Valve:

1. Actuator: Electric modulating with spring return.
2. Actuator: As specified in Division 23, Instrumentation and Control for HVAC.

F. Steam Trap: Inverted-bucket type, sized for a minimum of 3 times the maximum rated condensate flow of humidifier at 1/2-psiginlet pressure. G. Accessories:

1. Wall or Return-duct-mounting humidistat.
2. Duct-mounting, high-limit humidistat.
3. Aquastat mounted on steam condensate return piping to prevent cold operation of humidifier.
4. In-line strainer.
5. Airflow switch for preventing humidifier operation without airflow. H. Capacities and Characteristics: Refer to Schedules.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine ducts, air-handling units, and conditions for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in for piping systems to verify actual locations of piping connections before humidifier installation.

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

3.2 INSTALLATION

A. Install humidifiers with required clearance for service and maintenance Maintain path, downstream from humidifiers, clear of obstructions as required by ASHRAE 62.1.

B. Seal humidifier manifold duct or plenum penetrations with flange.

C. Install humidifier manifolds in metal ducts and casings constructed according to SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."

D. Install galvanized or stainless-steel drain pan under each manifold mounted in duct.

1. Construct drain pans with connection for drain; insulated and complying with ASHRAE 62.1.
2. Connect to condensate trap and drainage piping.

3. Extend drain pan upstream and downstream from manifold a minimum distance recommended by manufacturer but not less than required by ASHRAE 62.1.

E. Install manifold supply piping pitched to drain condensate back to humidifier.

F. Install drip leg upstream from steam trap a minimum of 12 inches tall for proper operation of trap.

G. Equipment Mounting: Install steam generator on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases specified in Division 03, Cast-in-Place Concrete. Division 03, Miscellaneous Cast-in-Place Concrete.

1. Coordinate sizes and locations of concrete bases with actual equipment provided.
2. Construct bases to withstand, without damage to equipment, seismic force required by code.
3. Construct concrete bases 4-inch, 6-inch or 8-inch high and extend base not less than 6 inchesin all directions beyond the maximum dimensions of steam generator, unless otherwise indicated or unless required for seismic anchor support.
4. Minimum Compressive Strength: 5000 psi, 4500 psi, 4000 psi, 3500 psi, or 3000 psiat 28 days.
5. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inchcenters around the full perimeter of concrete base.
6. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base, and anchor into structural concrete floor.
7. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
8. Install anchor bolts to elevations required for proper attachment to supported equipment.

H. Install seismic restraints on humidifiers. Seismic restraints are specified in Division 23, Vibration and Seismic Controls for HVAC Piping and Equipment.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

1. Install piping adjacent to humidifiers to allow service and maintenance.
2. Install shutoff valve, strainer, backflow preventer, and union in humidifier makeup line.

B. Install electrical devices and piping specialties furnished by manufacturer but not factory mounted.

C. Install piping from safety relief valves to nearest floor drain.

D. Ground equipment according to Division 26, Grounding and Bonding for Electrical Systems.

E. Connect wiring according to Division 26, Low-Voltage Electrical Power Conductors and Cables.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.

B. Perform tests and inspections and prepare test reports.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing. C. Tests and Inspections:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Remove and replace malfunctioning units and retest as specified above.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain humidifiers. Refer to Division 01, Demonstration and Training.

END OF SECTION