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Project Manual
VOLUME 2
JANUARY 13, 2023
G&HA#: 21541
SCO ID#: 21-23068-10A

Architect
Glavé & Holmes Architecture
2101 East Main Street
Richmond, VA 23223
(804) 649-9303
(804) 343-3378 fax
www.glaveandholmes.com

Structural Engineer
Lynch Mykins Structural Engineers, P.C.
1519 Summit Ave Suite 101
Richmond, VA 23230
T: 804-346-3935

MEF Engineer
Mueller Associates, Inc.
1306 Concourse Drive #100
Linthicum Heights, MD 21090
T: 410-646-4500

UNCP LIVERMORE LIBRARY SPECIAL COLLECTIONS

PROFESSIONAL SEALS

ARCHITECT OF RECORD

STRUCTURAL ENGINEER

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ELECTRICAL ENGINEER

FIRE PROTECTION ENGINEER

Quality Control:

"A quality control/quality assurance check has been made on this project's documents and corrections have been made. The undersigned states that these plans and specifications submitted for review are complete and ready for bidding."
Signed:

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SECTION 230500 - COMMON WORK RESULTS FOR MECHANICAL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:

1. Coordination drawings.
2. Piping materials and installation instructions common to most piping systems.
3. Piping flexible connectors.
4. Dielectric fittings.
5. Mechanical sleeve seals.
6. Sleeves.
7. Escutcheons.
8. Motor starting equipment.
9. Drip pans.
10. Grout.
11. Packing material for penetrations.
12. Equipment installation requirements common to equipment sections.
13. Painting and finishing.
14. Concrete bases.
15. Supports and anchorages.
16. Inspection of pressure vessels.
17. Accessibility.
18. Rigging of equipment.
19. Flashing.
20. Commissioning.

B. Related Sections include the following:

1. Section 017419 “Construction Waste Management and Disposal” for waste management requirements.
2. Section 018113 “Sustainable Design Requirements- LEED” for additional requirements related to the LEED certification process.

    a. Most of the mechanical systems are included in the Commissioning Program. Refer to the following specification sections for requirements associated with Commissioning:

    b. Section 019113 “General Commissioning Requirements”.

1.3 DEFINITIONS

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

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

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

D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings, in floor plenums and in duct shafts.

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. Conditioned Space: Finished spaces and exposed interior spaces that are air conditioned. Examples include offices, corridors, performance spaces, etc., that are served by air conditioning equipment. Return-air plenums are not conditioned space.

G. Return-air Plenums: Space between ceiling and structure above, and underfloor plenums when return air is transferred from space to plenum in lieu of directly ducting return air from the space.

H. Provide: Furnish and install.

I. Directed: Directed by the Construction Manager.

J. Indicated: Indicated by the Contract Documents.

K. K-Factor: Number of British thermal units of heat transmitted per square foot per degree Fahrenheit temperature difference through a material with flat, parallel sides one inch apart.

L. The following are industry abbreviations for rubber materials:
   1. EPDM: Ethylene-propylene-diene terpolymer rubber.
   2. NBR: Acrylonitrile-butadiene rubber.

1.4 SUBMITTALS

A. Product Data: For the following:

   1. Piping flexible connectors.

   2. Dielectric fittings.

   3. Mechanical sleeve seals.

   4. Escutcheons.

B. Welding certificates.

C. Certificates of Compliance for pressure vessels.

D. Samples, drawings, specifications, catalogs, etc., submitted for approval shall be properly labeled indicating specific service for which material or equipment is to be used.

E. Submit access door locations to the Architect for approval. Equipment requiring access doors shall not be installed prior to approval of access door locations.

F. For systems included in the Commissioning Program provide one additional copy of the submittal for the Commissioning Agent.

G. Coordination Drawings:

1. Provide coordination drawings in accordance with Section 013100 “Project Management and Coordination”. Provide coordination drawings detailing the work in the entire project.

2. Detail major elements, components, and systems of mechanical equipment and materials in relationship with other systems, installations, and building components (i.e. electrical, plumbing, sprinkler, structural and architectural work). Show space requirements for installation and access. Indicate if sequence and coordination of installations are important to efficient flow of the Work. Include the following:

   a. Planned piping layout, including valve and specialty locations and valve-stem movement.

   b. Clearances for installing and maintaining insulation.

   c. Clearances for servicing and maintaining equipment, accessories, and specialties, including space for disassembly required for periodic maintenance.

   d. Equipment and accessory service connections and support details.

   e. Fire-rated wall and floor penetrations.

   f. Sizes and location of required concrete pads and bases.

   g. Scheduling, sequencing, movement, and positioning of large equipment into building during construction.

   h. Floor plans, elevations, and details to indicate penetrations in floors, walls, and ceilings and their relationship to other penetrations and installations.

   i. See Section 233113 “Metal Ducts” for ductwork installation drawing requirements.

   j. Reflected Ceiling Plans:
      1) Ceiling suspension assembly members.
      2) Other systems installed in same space as ducts and pipes.
      3) Ceiling- and wall-mounting access doors and panels required to provide access to dampers and other operating devices.
      4) Ceiling-mounting items, including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
      5) Refer to architectural ceiling plans for additional requirements.

   k. Access Door Locations: Equipment requiring access doors shall not be installed prior to approval of access door locations.

H. Building Information Modeling: Utilize for preparing coordination drawings. Submit hard copy color views of representative sections and plans, and submit electronic file of the model in Revit or Navisworks.

I. Qualification Data: for Installer.

J. Field quality-control test reports.

K. Operation and Maintenance Data:

1. Operation and maintenance manuals and record product data as specified in Section 017823 “Operation and Maintenance Data”.

2. Bound sets of approved submittals for items utilized on the project. Manufacturers' advertising literature or catalogs will not be acceptable for operating and maintenance instructions.

L. Record Documents:

1. See Section 017200 “Project Record Documents” for general requirements.

1.5 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. Electrical Characteristics for Mechanical Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. Any additional cost will not be reimbursed by the Owner. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

D. Give necessary notices and obtain required permits. Pay fees and other costs, including utility connections or extensions in connection with the work. File necessary plans, prepare documents and obtain necessary approvals of governmental agencies having jurisdiction. Obtain required certificates of inspection and deliver same to the Architect before request for acceptance and final payment for the work.

E. Materials furnished and work installed shall comply with the latest issue of the codes, rules, regulations, and recommendations.

F. Installer Qualifications:

1. Mechanical contractors shall be a North Carolina-licensed HVACR Master or Master Restricted contractor who is qualified in the areas of work included in the Project.

2. The successful contractor shall agree to employ, in skilled positions, only individuals who hold valid licenses issued by the State HVACR Board of the Department of Labor, Licensing and Regulation to provide, or assist in providing, heating ventilating, air conditioning, or refrigerating system installation or service required for the project.

3. If the successful contractor subcontracts any or all of the heating, ventilating, air conditioning, or refrigerating system installation or service required for the project, the subcontractor must possess the appropriate license required and issued by the State HVACR Board.

4. All heating, ventilating, air conditioning, and refrigerating system subcontractors shall consistently use only individuals who hold the appropriate licenses issued by the State HVACR Board to provide or assist in providing heating, ventilating, air conditioning, and refrigerating system installation or service required for a project.

5. HVAC Refrigeration work to be performed following licensing requirements of Federal EPA Certified Refrigeration Mechanics.

1.6 DELIVERY, STORAGE, AND HANDLING

A. See Section 016000 “Product Requirements” for general requirements.

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

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

D. Proper and suitable tools, equipment and appliances for the safe and convenient handling and placing of materials and equipment shall be used. During loading, unloading, and placing, care shall be taken in handling the equipment and materials so that no equipment or materials, including Owner furnished, are damaged.

E. Mechanical equipment delivered to the job site shall be stored under roof or other approved covering, on pedestals above the ground. Enclosures for equipment shall be weatherproof.

1. Any motors involved in the work that are not totally enclosed and electrical/electronic components shall be stored in a heated area with a minimum temperature of 50 deg. F.

2. Valves shall be stored under roof on wood pedestals above ground. Pipe for project use shall be stored above grade and in such a manner to prevent entrance of foreign materials.

3. Pipe shall be fitted with end caps or seals to prevent moisture and debris from entering pipe.

4. Insulation shall be stored under roof or in trailers, adequately protected from the weather.

5. Follow written instructions and recommendations of the manufacturer and requirements of the Architect in lubrication, protection and maintenance of equipment during storage.

F. If materials or equipment are found to be in poor condition at the time of being installed, the Architect may, at his discretion, order the Contractor to furnish and install new equipment or materials at no cost to the Owner.

1.7 COORDINATION

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

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

C. Coordinate requirements for access panels and doors for mechanical items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Section 083113 "Access Doors and Frames."

1.8 EQUIPMENT START-UP AND INITIAL OPERATION

A. See Section 019113 “General Commissioning Requirements.”

B. No equipment shall be operated for testing or trial use until there has been full compliance with the equipment manufacturers' specifications and instructions for lubrication, alignment, direction of rotation, balance, and other applicable considerations.

C. Particular care shall be taken to verify that equipment is completely assembled and properly lubricated, and grease and oil cases and reservoirs have been filled to the correct level with the recommended lubricant.

D. Where specified, provide services of the manufacturer or his authorized representative to witness, supervise, or assist in the installation and start-up of equipment provided under this Division.

1.9 WARRANTY

A. See Section 016000 “Product Requirements” for general requirements.

B. Provide service of the equipment manufacturer or his authorized representative where required in other specification sections.

C. Provide extended equipment warranties where specified under other Division 23 sections.

1.10 DRAWINGS

A. The contract drawings are diagrammatic and indicate the general arrangements of systems and work included in the Contract. Do not scale the drawings. Consult the architectural and structural drawings and details for exact location of structure and equipment; where same are not precisely located, obtain this information prior to start of work.

B. Layout of equipment indicated on drawings shall be checked and compared against drawings of trades, and exact locations and clearances for servicing determined using approved shop drawings of such equipment. Where the equipment furnished differs in physical character from that specified or indicated or where physical interference occurs, consult with Architect as to proper location of equipment. Prepare and submit for approval dated and dimensioned drawings correcting such interference's.

C. Although the location of materials and equipment may be shown on the drawings in a certain place, the construction may develop conditions that render this location inaccessible or impractical. In such cases, before fabricating and installing the work, the Contractor shall call the condition to the attention of the Architect for direction. When requested by the Architect a detailed drawing of the proposed departure due to field conditions, or their causes, shall be submitted by the Contractor for approval. The Architect shall make final written decisions as to the conditions, which require the changing of work.

D. RECORD DRAWINGS

E. See Section 017200 "Project Record Documents" and Section 017700 "Closeout Procedures" for general requirements.

F. Carefully record the actual locations of each piece of concealed equipment, control devices, pipe, valves, ducts, terminal units, etc., including dimensions to locate underground work, and work when different from the contract drawings.

1.11 OPERATING AND MAINTENANCE INSTRUCTIONS

A. See Section 017700 "Closeout Procedures" for general requirements of demonstration and training.

B. Upon completion of work and of tests, furnish the necessary skilled labor and helpers for operating and demonstrating the systems and equipment.

C. The instructor shall be thoroughly familiar with parts of the installation on which he is to give instruction and shall be trained in operating theory as well as practical operation and maintenance work. Employ factory trained instructors wherever necessary and as specified. Provide Owner with a DVD recording of the instruction sessions.

D. Instructions shall include a general description of each system together with specific instructions describing routine and emergency procedures required of the building personnel for operating and maintaining each system. The instructions shall include the name or label, location, and function of operating equipment and controls. Operating modes and the procedures for indexing each mode shall be clearly described. Include lubrication charts and schedules of frequency of lubrication for equipment, designating each point of lubrication and type of lubricant to be used. Listings of names, addresses, and phone numbers of the service organizations for each item of equipment and a typewritten maintenance schedule for same shall be included.

E. Provide operation and maintenance manuals and record product data as specified in Section 017200 "Project Record Documents."
   1. Submit Division 23 operation and maintenance manuals prior to substantial completion.

1.12 FIRE PROTECTION

A. See Section 015000 "Temporary Facilities and Controls" for general requirements.

B. As minimum, one five-pound CO_2 extinguisher shall be provided with each work crew.

1.13 SINGULAR NUMBER

A. Where any device or part of equipment is herein referred to in the singular number, such as "valve", such reference applies to as many such devices as are required to complete the installation, shown, implied or otherwise, as indicated on the drawings.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:
1. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.

2.2 PIPE, TUBE, AND FITTINGS

A. General: All pipe, fittings and welding materials shall be manufactured in the United States of America.

B. Refer to individual Division 23 piping Sections for pipe, tube, and fitting materials and joining methods.

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

2.3 JOINING MATERIALS

A. General:

1. Bolting of piping components shall be accomplished with bolts, nuts, and gaskets suitable for the service conditions to be encountered in accordance with proven industry standards. Notify Engineer prior to installation of work, if materials noted herein are at variance with above.

2. Adhesives and sealants applied within the building waterproofing envelope: Comply with low-emitting requirements in Division 01 Section “Indoor Air Quality Requirements.”

3. Refer to individual Division 23 piping Sections for special joining materials not listed below.

B. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. Gaskets for water services shall be suitable for operating conditions of 40 to 180 degrees F at 150 psig. Gaskets shall have 1/16" thickness and be as manufactured by Thermoseal, Model KLINGER-sil C-6400 or approved equal.

2. Flange gaskets for dielectric connections shall be one piece factory cut insulating gaskets between flanges and be constructed of ASTM D 229 electrical insulating

material of 1000 ohms minimum resistance. Provide silicon-coated fiberglass insulating sleeves between the bolts and the holes in flanges; bolts may have reduced shanks of a diameter not less than the diameter at the root of threads. Provide 0.125 inch thick high-strength insulating washers next to flanges and provide stainless steel flat circular washers over insulating washers and under bolt heads and nuts. Provide bolts 0.5 inch longer than standard length to compensate for the thicker insulating gaskets and the washers under bolt heads and nuts.

3. Flange Connections: Flange bolts and studs to conform to ASTM A 307, Grade B; and materials for nuts shall conform to ASTM A 194/A 194M, Grade 2. Dimensions of bolts, studs, and nuts shall conform to ANSI B18.2.1 and ASME/ANSI B18.2.2 with threads conforming to ASME B1.1 coarse type, with Class 2A fit for bolts and studs, and Class 2B fit for nuts. Bolts or bolt-studs shall extend completely through the nuts and may have reduced shanks of a diameter not less than the diameter at root of threads. Carbon steel bolts shall have American Standard regular square or heavy hexagon heads and shall have American Standard heavy semifinished hexagonal nuts, conforming to ANSI B18.2.1 and ASME/ANSI B18.2.2.

C. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.

D. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

E. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAg1, silver alloy for refrigerant piping, unless otherwise indicated.

F. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

2.4 PIPING FLEXIBLE 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 or piping connected.

3. Performance: Capable of 3/4-inch misalignment.

4. CWP Rating: 150 psig.

5. Maximum Operating Temperature: 250 deg F.

B. Flexible connectors in piping smaller than 2 inches shall for have braided hose with sweat or threaded ends. Provide Mason Model MN in steel piping and Model CPSB in copper piping.

C. Flexible connectors for natural gas piping are specified in Section 231123 “Fuel Gas Piping.”

D. Rubber Flexible Connectors: ASTM F 1123, fabric-reinforced rubber with external control cables and complying with FSA's "Technical Handbook: Non-Metallic Expansion Joints and Flexible Pipe Connectors."

1. Manufacturers:

a. Flexicraft Industries.

b. Mason Industries, Inc.; Mercer Rubber Co.

c. Metraflex, Inc., Model MSRC.

d. Vibration Mountings & Controls, Inc.

2. Spherical Type: Single or multiple spheres (generally).

a. Minimum Pressure and Temperature Ratings for NPS 2 to NPS 12: 140 psig at 200 deg F.

3. Material: EPDM.

4. End Connections: Full-faced, integral, steel flanges with steel retaining rings.

2.5 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. Dielectric unions are not acceptable.

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

C. Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 150-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.

D. 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.

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

E. Dielectric Waterway Fittings: 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. Victaulic Co. of America, Series 47

2.6 MECHANICAL SLEEVE SEALS

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

1. Manufacturers:

a. Advance Products & Systems, Inc.

b. Calpico, Inc.

c. Metraflex Co.

d. Pipeline Seal and Insulator, Inc.

e. Thunderline Linkseal.

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 of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.7 SLEEVES

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

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

C. Cast Iron: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

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

1. Underdeck Clamp: Clamping ring with set screws.

2.8 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.

D. 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 or exposed-rivet hinge, set screw, and chrome-plated finish.

2.9 DRIVES FOR MACHINERY

A. Equip each motor driven machine with a V-belt drive except those that are directly connected. Factory designed and assembled belt drives that do not conform to the following will be rejected.

B. Select each drive according to the rating and recommendation of the manufacturer (and as specified in other Sections) for the service with which used, giving proper allowance for sheave diameter, center distance, and arc of contact.

C. Belts shall be constructed of endless reinforced cords of long staple cotton, nylon, rayon, or other suitable textile fibers imbedded in rubber. Use belts having correct cross section to fit properly in the sheave grooves. Carefully match belts for each drive.

D. Unless otherwise specified, motor sheaves shall be adjustable pitch type so selected that the required fan rotation speed will be obtained with the motor sheave set approximately in mid-position and have the specified pitch diameter in that position.

1. Motors driven by variable frequency controllers shall utilize fixed pitch type.

E. Select the motor of a capacity needed to operate the equipment at the specified mid-position operating condition, and so that they have a nameplate rating of not less than 10 percent greater than the total of actual brake horsepower and drive loss at specified capacity. Where non-overloading of the motors is specified, select the motor capacity rating at closed position of the motor sheave. In no case shall motors be a smaller size than those scheduled.

F. Do not select fan sheave smaller in diameter than 30 percent of the fan wheel diameter.

G. Construct sheave of cast iron or steel, bored to fit properly on the shafts and secured with key ways of proper size, except that set screws may be used for sheaves having 1/2-inch or smaller bores.

H. Provide OSHA approved guards for belt drives, with instrument openings at the fan and motor sheaves, constructed in accordance with SMACNA standards, ANSI B15.1, and OSHA 29 CFR 1910.219. Submit shop drawings for approval.

2.10 MOTOR STARTING EQUIPMENT

A. Unless otherwise specified, motor control centers, starters, disconnect switches, combination starters and disconnect switches and variable frequency controllers shall be provided by the Division 26 Contractor, except as specified to be factory furnished with packaged equipment under this Division.

2.11 DRIP PANS

A. Where possible to run mechanical piping elsewhere, do not run mechanical piping directly above electrical (or electronic) work; otherwise provide drip pans under mechanical piping, sufficient to protect electrical work from drips. Locate pan immediately below piping, and extend a minimum of 6" on each side of piping and lengthwise 18" beyond the protected equipment. Fabricate pans of reinforced metal 2" deep, with rolled edges and soldered or welded seams; metal shall be 20 gage copper, or 18 gage steel with 2 oz. zinc finish hot dipped after fabrication. Provide 3/4" copper drainage piping, discharging to nearest floor drain, service sink, or as directed.

2.12 GROUT

A. Materials shall comply with LEED Credits EQ 4.1 and 4.2 for low emitting materials.

B. Description: ASTM C 1107, Grade B, non-shrink and nonmetallic, dry hydraulic-cement 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.

2.13 PACKING MATERIAL FOR PENETRATIONS

A. Materials shall comply with LEED Credits EQ 4.1 and 4.2 for low emitting materials.

B. Mineral fiber; non-combustible; resistant to water, mildew, and vermin. Expanding resilient foams manufactured for this purpose are an acceptable alternative only if the material density is at least 3.0 pounds per cubic foot.

PART 3 - EXECUTION

3.1 PIPING SYSTEMS - COMMON REQUIREMENTS

A. Install piping according to the following requirements and Division 21, 22 and 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 by the Architect.

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

D. Install piping 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.

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 manufactured, nonmetallic flexible pipe connectors according to Fluid Sealing Association's "Technical Handbook: Non-Metallic Expansion Joints and Flexible Pipe Connectors," and manufacturer's written instructions. Refer to Section 230548 “Mechanical Vibration Control” for additional requirements.

1. Install piping and flexible connectors such that control rods do not short circuit the flexible connectors.

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

1. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
2. Chrome-Plated Piping: One-piece, cast-brass type with polished chrome-plated finish.
3. Insulated Piping: One-piece, stamped-steel type with set screws.
4. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type.

5. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge and set screw.

N. Unless indicated otherwise, sleeves are not required for core-drilled penetrations in solid concrete construction, except when located in floors and walls of mechanical equipment areas. Seal annular space between pipe or pipe insulation and concrete as specified for sleeves.

O. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs.

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

   a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other potential wet areas 4 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 walls and slabs as walls and slabs are constructed.

3. Unless indicated or specified otherwise, 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 penetrating concrete and masonry construction.

   b. Steel Sheet Sleeves: For pipes penetrating gypsum-board or similar construction partitions and ceilings.

   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 Section 076200 "Sheet Metal Flashing and Trim" for flashing.
      1) Seal space outside of sleeve fittings with grout.

4. Seal space outside of sleeves with grout for penetrations of concrete and masonry and with approved joint sealant for gypsum board assemblies.

5. 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.

6. Install sleeves for pipes passing through walls, slabs, and ceilings of acoustic sensitive spaces in accordance with details of architectural drawings. Seal penetrations in accordance with details.

P. 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.

Q. 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.

R. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Section 078413 "Penetration Firestopping" for materials.

S. Verify final equipment locations for roughing-in.

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

U. Refer to installation details on drawings for additional requirements.

V. PIPING JOINT CONSTRUCTION

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

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

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

Z. 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.

AA. 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.

BB. 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.

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

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

EE. 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. ABS Piping: Join according to ASTM D 2235 and ASTM D 2661 Appendixes.

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

4. 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.

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

6. PVC to ABS Nonpressure Transition Fittings: Join according to ASTM D 3138 Appendix.

3.2 PIPING CONNECTIONS

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

1. Install unions, in piping NPS 2 and smaller, adjacent to each control 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. Install dielectric flanges and waterway fittings to connect piping materials of dissimilar metals.

B. Welded Fittings:

1. Use fittings for changes in direction of piping and for connections.

2. Reducing branch connections in steel piping may be made with forged branch outlet reducing fittings for branches two or more pipe sizes smaller than mains.

3. Branch outlet fittings shall be forged, flared for improved flow where attached to the run, reinforced against external strains, and designed to withstand full pipe bursting strength. Stab type connections will not be permitted.

3.3 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 mechanical equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations. In no case shall equipment be installed with service clearance less than manufacturer’s recommendations.

D. Install equipment to allow right of way for piping installed at required slope.

E. Refer to installation details on drawings for additional requirements.

3.4 PAINTING

A. Painting of mechanical systems, equipment, and components is specified in Section 099113 "Exterior Painting" And Section 099123 “Interior Painting”.

B. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish. Provide complete new finish if, in the opinion of the Architect or Owner, the factory finishes are severely damaged.

C. Miscellaneous requirements include:

1. Touch up factory finishes and provide complete new finish if, in the opinion of the Architect or Owner, the factory finishes are severely damaged.

2. Touch up threads of zinc coated screwed pipe with Rustoleum primer and one coat of enamel conforming to painting specification.

3. Paint behind grilles and registers in finished areas with two coats of flat black paint following surface preparation of the zinc coated metal.

4. Exposed hangers shall be field painted with Rustoleum primer and one coat of enamel conforming to painting specification.

3.5 CONCRETE BASES AND PADS FOR EQUIPMENT

A. Concrete Bases and Pads: 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 6 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 Section 033000 "Cast-in-Place Concrete."

8. Refer to Section 230548 “Mechanical Vibration Control” for additional requirements.

3.6 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Refer to Division 05 for structural steel.

B. Provide supplemental structural members as required to adequately support piping and equipment.

C. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor mechanical materials and equipment.

D. Field Welding: Comply with AWS D1.1.

3.7 ERECTION OF TEMPORARY WOOD SUPPORTS AND ANCHORAGES

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

B. Select fastener sizes that will not penetrate members if opposite side will be exposed to view or will receive finish materials. Tighten connections between members. Install fasteners without splitting wood members.

C. Attach to substrates as required to support applied loads.

3.8 GROUTING

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

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

C. Provide forms as required for placement of grout.

D. Avoid air entrapment during placement of grout.

E. Place grout, completely filling equipment bases.

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

G. Place grout around anchors.

H. Cure placed grout.

3.9 INSPECTION OF PRESSURE VESSELS

A. For the purpose of obtaining and having the Owner’s buildings insured by any commercial insurance carrier, the Contractor shall arrange for the inspection of pressure vessels installed during construction.

1. Contractor shall obtain permits associated with the pressure vessels.

B. The Contractor shall contact the Office of Boiler and Pressure Vessel Inspections, State of North Carolina, and arrange for the inspections.

C. The Office shall be notified at least 30 days prior to installation.

D. After such inspections are carried out by the State Inspector’s office, Certificates of Compliance will be issued to the Contractor of record to be turned over to the Owner’s representative for compliance with current insurance regulation as part of the Project Documents.

E. Examples of pressure vessels include the boilers, expansion tanks, air separators, water heaters, and water storage tanks.

3.10 WORKMANSHIP

A. Furnish the services of an experienced full time field superintendent who shall be constantly in charge of the installation of the work provided under this Division. Superintendent shall have demonstrated experience with projects of comparable size and complexity and shall be approved by the Architect.

B. The quality of workmanship required in the execution of the work shall be the finest and highest obtainable, working with the materials specified. Workmanship shall be satisfactory to the Architect and his decision as to acceptable quality is final.

3.11 EQUIPMENT CONNECTIONS

A. Equipment shall be installed and connected in accordance with the best engineering practice and in accordance with manufacturer's instructions and recommendations. Auxiliary piping, valves, and electric connections recommended by the manufacturer or required for proper operation shall be provided.

B. See Division 26 for electrical power wiring and final connections to motors and equipment requiring electric service. Temperature control wiring between starters and controlling devices and interlock wiring are specified in Section 230900 “Instrumentation and Control for HVAC”. Verify that the proper power wiring services are installed prior to starting the equipment specified in Division 23.

3.12 CUTTING AND PATCHING

A. See Section 017310 “Cutting and Patching” for general requirements.

B. Cutting and patching of building materials shall be performed in a neat and workmanlike manner. Surfaces, which are damaged by the Contractor, shall be repaired or provided with new materials. Patching and materials shall be done with materials and methods similar to adjacent work, subject to approval of the Architect. Structural members shall not be cut or penetrated unless indicated on the drawings and verified in the field with the Construction Manager. Holes cut through concrete and/or masonry to accommodate work under this Division shall be cut by reciprocating or rotary non-percussive methods.

3.13 SURVEYS AND MEASUREMENTS

A. Base measurements, both horizontal and vertical, from established benchmarks. Work shall agree with these established lines and levels. Verify measurements at site and check correctness of same as related to the work.

B. Should the Contractor discover any discrepancy between actual measurements or conditions, and those indicated which prevent following good practice or the intent of the drawings and specifications, he shall notify the Construction Manager and shall not proceed with his work until he has received instruction from the Construction Manager.

3.14 RIGGING OF EQUIPMENT

A. Verify the rigging path for equipment prior to start of work or ordering of materials. Verify accessways and weight carrying capacity of building features, including elevators, floors, walls, ceilings, roofs, and related features. When equipment or sections of equipment are larger than available accessways, equipment shall be ordered in a knocked-down configuration for re-assembly at the site. Submit in writing to Architect where problems are encountered that may prohibit rigging of equipment into its space with the proposed solutions.

B. Use planking or cribbing as required to protect adjoining construction from damage. Protect equipment from damage until construction is completed.

3.15 WELDING

A. Welding piping shall comply with the provisions of the latest revision of the ASME Code for Pressure Piping, ANSI/ASME B31.1 - Power Piping, and ANSI/ASME B31.9 - Building Services Piping. Contractor shall comply with requirements of federal, state or local agencies having legal jurisdiction that are more stringent than the above ANSI/ASME Codes.

B. State, county, and city fire prevention code requirements, fire and safety regulations, and NFPA 241 shall be complied with, including the provision of appropriate portable fire extinguishers. Prior to performing welding within the building, notify the Construction Manager in advance of areas where welding will occur, and submit for approval a plan for protection of the building and occupants. Proceed only upon receipt of Construction Manager’s approval and provide reasonable barriers, coverings, etc., as required or requested by the Construction Manager for protection of the installed work and building occupants. In regards to welding operations within the building, maintain a negative pressure within the work area to prevent the migration of smoke and fumes to occupied areas of the building. Provide temporary exhaust fans and smoke removal systems as required - discharge of smoke and fumes shall be to the building exterior in a manner to not be recirculated back into building through areaways, windows, etc. and away from public accessways.

C. Provide single-vee type butt welds, unless specified otherwise. Joint configuration shall conform to ANSI B16.25.

D. Before welding is performed, submit a copy of the Contractor's Standard Welding Procedure Specification together with the Procedure Qualification Record as required by Section IX of the ASME Boiler and Pressure Vessel Code.

E. Before a welder shall perform welding, submit a copy of the Manufacturer's Record of Welder or Welding Operator Qualification Tests as required by Section IX of the ASME Boiler and Pressure Vessel Code.

F. Welds shall have penetration complete to the inside diameter of the pipe and the recommended spacing and bevels between ends of pipe prior to welding shall be used to assure full penetration for high pressure steam piping. Weld penetrations for pipe service conditions shall be in accordance with the applicable ANSI/ASME Code.

G. Visual and nondestructive examinations shall be performed to detect the surface and internal discontinuities in completed welds by an independent testing agency hired by the Construction Manager. The Contractor shall fully cooperate with an independent testing agency so that welds can be examined by the independent testing agency. The types and extent of non-destructive examinations required for pipe welds are as shown in Table 136.4 of ASME Code for Pressure Piping, ANSI/ASME B31.1-Power Piping and as contained herein. If requirements for visual and nondestructive examinations are to be other than contained herein, the degree of examination and basis of rejection shall be a matter of prior written agreement between the Construction Manager and the independent testing agency. The extent of visual and non-destructive examinations shall be as follows:

1. The independent testing agency shall randomly select and test a minimum of 20% of the total length or number of piping welds by utilizing radiograph, ultrasonic testing, sectioning or a combination of these methods as determined by the independent testing agency. If a random weld test reveals that a weld fails to meet the minimum quality requirements, 100 percent of the welds in that same group shall be tested at the Contractor's expense and at no additional cost to the Owner. If the additional welds examined meet the quality requirements, the entire group of welds represented shall be accepted and the defective welds shall be repaired. If any of the additional welds examined also fail to meet the quality requirements as determined by the independent testing agency, that entire group of welds shall be rejected. Remove and re-weld rejected welds or examine rejected welds (at the Contractor's expense and at no additional cost to the Owner) and remove and re-weld defects.

2. Welds shall be visually examined as follows:

3. Before welding -- for compliance with requirements for joint preparation, placement of backing rings or consumable inserts (if used), alignment and fit-up, and cleanliness.

4. During welding -- for conformance to the qualified welding procedure.

5. After welding -- for cracks, contour and finish, bead reinforcement, undercutting, overlap, and size of fillet welds.

6. Welds determined to be unacceptable shall be removed and replaced by the Contractor, at no additional cost to the Owner, in accordance with the applicable standards. Repair defects discovered between weld passes before additional weld material is deposited. Wherever a defect is removed, and repair by welding is not required, the affected area shall be blended into the surrounding surface eliminating sharp notches, crevices, or corners. After defect removal is complete and before re-welding, re-examine the area by the same test methods that first revealed the defect to ensure that the defect has been eliminated. After re-welding, re-examine the repaired area by the same test methods originally used for that area. For repairs to base material, the minimum examination shall be the same as required for butt welds. Indication of a defect shall be regarded as a defect unless re-evaluation by non-destructive examination testing or by surface conditioning shows that no unacceptable indications are present. The use of foreign material to mask, fill in, seal, or disguise welding defects will not be permitted.

H. Pipe welds shall not be covered prior to examination by the independent testing agency. Should the independent testing agency encounter pipe joints that are covered, Contractor shall remove covering and replace with new covering, at no additional cost to the Owner, following examination by the independent testing agency. Coverings shall include, but not limited to, insulation, jacketing, outer conduit closure kits, special coatings, and backfill. Examinations of welds for the metal conduits for pre-insulated conduit piping systems may be covered without examination by the independent testing agency.

I. Welding at hangers, supports and plates to structural members shall conform to American Welding Society, Inc. AWS D1.1 Structural Welding Code Steel.

J. When requested by the independent testing agency or Architect, submit identifying stenciled test coupons made by any welder in question. The Contractor shall require a welder to retake the tests when, in the opinion of the Architect or independent testing agency, the work of the welder creates a reasonable doubt as to his proficiency. Tests, when required, shall be conducted at no additional expense to the Owner; and the welder in question shall not be permitted to work as a welder on this project until he has been re-qualified.

K. The use of backing rings shall be at the discretion of the installing Contractor provided that the Contractor prepares and aligns pipes precisely to melt through to the inside surface - making a full penetration weld. At the direction of the independent testing agency, the Contractor may be directed to use backing rings (at no additional cost to the owner) when deemed necessary by the independent testing agency after examination of the pipe welds.

L. When weld testing or examination is performed as required herein, the corresponding written certified test reports shall be submitted.

3.16 CLEANING

A. See Section 017700 “Closeout Procedures.”

B. Thoroughly clean exposed surfaces of equipment and material and leave in a neat, clean condition ready for painting. Finished painting will be as specified in Section 099113 “Exterior Painting" and 099123 “Interior Painting”.

C. After completion of installation, thoroughly clean dirt, rust, loose scale, oils and grease, and other foreign matter for work.

D. Clean all piping systems thoroughly of grease, metal shavings, welding beads or other refuse.

1. Provide temporary piping as required to properly flush, clean, and dispose of water from site.

2. Flush piping for minimum of 24 hours by use of portable pump or separate water supply to prevent damage to existing or new system pumps. Use cleaners and degreasers as specified in Section 232500.

3. After flushing, clean strainers of debris. Refill and vent water systems being sure to add water to completely fill system after venting.

E. Flush all systems with new potable water after pressure testing is complete and drain at low points. Continue flushing until water samples taken at all low points are clear of visible grease, dirt, and contaminants. Obtain written acceptance from Owner upon completion of flushing acknowledging Owner's acceptance of system cleanliness.

F. Clean all systems after flushing as follows:

1. Clean by flushing with water source to provide minimum 8 feet per second velocity until effluent is visibly as clean as the flushing medium.

G. Clean duct systems as herein specified under Division 23 Section “HVAC Air-distribution System Cleaning.”

3.17 PIPING SYSTEMS, GENERAL TESTING

A. Piping systems shall be pressure tested hydrostatically in accordance with applicable codes. Testing shall be done in accordance with the following procedures:

1. Before testing, complete the installation of each pipe line, including supports, hangers and anchors. Perform testing before insulation is field-applied. Clean piping and equipment of metal cuttings and foreign matter as they are installed.

2. Submit test procedures and schedules to the Engineer two weeks before testing starts. Test procedures and schedules shall be approved by the Engineer. All tests shall be witnessed and approved by the Owner or his designated representative.

3. Codes - Pressure test piping to assure integrity of material and workmanship in accordance with the applicable ANSI/ASME Code for Pressure Piping B31, the Plumbing Code, or NFPA Standards as applicable.

4. Pressure vessels, pumps, rotating and other mechanical equipment shall not be subject to the piping field pressure tests.

5. Equipment, instruments and piping specialties which are not to be included in the test shall be either disconnected from the piping and the end of the pipe blanked off by a blind flange, plug or cap, or isolated.

6. Test the piping in sections or circuits as required for the progress of the work.

7. Systems to be pressurized shall be provided with appropriate gages and pressure-relieving devices.

8. Test pressure readings may be taken at the lowest point in the line or system of lines, provided that the static head is added to the minimum test pressure.

9. Lines containing check valves shall have the source of test pressure located on the high-pressure side of the valves. Line control valves shall be set and maintained in a wide-open position.

10. Duration of Test - Maintain the test pressure for a sufficient time but not less than 4 hours to determine and locate any leaks.

11. Records - Provide a record of all tests. The record shall show line designation, test pressure, ambient temperature, date of test, retests, and signature of Owner's witness. If either testing or witnessing is waived, a note shall be made for each line so waived.

12. Hydrostatic Test Procedures - Test the piping system hydrostatically in accordance with the requirements of the applicable ANSI/ASME Code for Pressure Piping B31.

13. Repair of Line Leaks - Comply with the following procedures for repair of leaks. In each case, a retest shall be necessary after repairs are made and shall be made at no additional cost to the Owner.

    a. Soldered/Brazed Joints - Remove solder/brazing alloy and reapply with proper flux.
    b. Flanged End Joints - Check to determine flange end alignment and that all bolts are uniformly tightened with the required torque. If leak persists, depressurize the line, remove gasket, examine flange end faces, and insert new gasket.
    c. Threaded Joints - Tighten joint to a reasonable torque. If leak does not stop, replace pipe and/or fittings. Do not use pipe dope or cement to stop pipe leaks.
    d. Gasketed Joints - Remove existing gasket and insert new gasket.
    e. Welded Joints - Replace joint.
    f. Leaks in Material - Leaks located in pipe material shall require the replacement of that section of pipe or fitting and repeat of the test from the beginning. Caulking, welding or epoxy is not permitted. Repair all damage caused by leaks. Repairs and retest shall be made at no additional cost to the Owner.

3.18 ACCESSIBILITY

A. Locate equipment that must be serviced, operated or maintained, in fully accessible positions. Equipment shall include, but not be limited to, terminal units, coils, valves, motors, controllers, ATC dampers, drain points, cleanouts, etc. Provide adequate means to access equipment for repair and maintenance including capabilities for platforms, fall protection systems, and anchorage points.

B. Where required or where directed, provide access doors. Locate equipment and associated access doors in accordance with the architectural reflected ceiling plan drawings (not all required access doors are indicated on the plans, only the ones that the Architect has specific requirements for placement). Doors installed in fire-rated walls or shafts shall be labeled and shall match rating of the construction. Doors shall be sufficient size to allow access to components, except minimum size shall be 12" x 16". Where equipment requires access to various parts, such as air terminal units require access to the controller and valve and piping appurtenances for the reheat coil, locate appurtenances requiring access such that all devices can be maintained from single door. For items that require access greater than 3 feet above the ceiling, provide minimum 4 feet x 4 feet removable ceiling panel to facilitate top of a folding ladder placed above the ceiling plane. Access doors are specified in Section 083113 “Access Doors and Frames.”

C. The Contractor at no expense to the Owner shall rework equipment deemed inaccessible by the Architect.

D. Refer to Section 233300 “Air Duct Accessories” for access doors installed in ductwork.

3.19 FLASHING

A. See Division 07 sections.

B. Openings for pipes and ductwork through waterproofed roof areas shall be flashed.

3.20 COMMISSIONING

A. Contractor shall be responsible for the installation verification and start-up of the mechanical equipment included in the Commissioning Program. Refer to Division 01 for details regarding the equipment and installation verification and start-up requirements for the Commissioning Program.

B. Pre-functional performance testing: Contractor shall perform pre-functional performance testing prior to engaging Cx Agent and Owner for witnessing of functional performance testing.

C. The functional performance testing of equipment included in the Commissioning Program shall be provided in accordance with Division 01 and Division 23 commissioning requirements. The functional performance test shall include a demonstration by the installation contractor to verify that the equipment functions in accordance with the design intent.

D. Most of the mechanical systems are included in the Commissioning Program. Refer to the following specification sections for requirements associated with Commissioning:

1. Section 019113 “General Commissioning Requirements”.

END OF SECTION

SECTION 230513 - COMMON MOTOR REQUIREMENTS FOR MECHANICAL EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

B. Related Sections include the following:

1. Refer to Section 018113 “Sustainable Design Requirements” for additional requirements.

a. Most of the mechanical systems are included in the Commissioning Program. Refer to the following specification sections for requirements associated with Commissioning:

b. Section 019113 “General Commissioning Requirements”.

1.3 DEFINITIONS

A. Factory-Installed Motor: A motor installed by motorized-equipment manufacturer as a component of equipment.

1.4 SUBMITTALS

A. Product Data: For each type and size of motor, provide nameplate data and ratings; shipping, installed, and operating weights; enclosure type and mounting arrangements; size, type, and location of winding terminations; conduit entry and ground lug locations; and information on coatings or finishes.

B. Shop Drawings: Dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Include the following:

1. Each installed unit's type and details.

2. Nameplate legends.

3. Diagrams of power, signal, and control wiring. Provide schematic wiring diagram for each type of motor and for each control scheme.

C. For each motor or motor-driven equipment including at least the following:

1. Unit or motor data defining efficiency and power factor at incremental loads (10% or smaller increments) from full load to no load without power factor correction.

2. Maximum allowable power factor correction capacitance which will not cause over-excitation at no load.

3. Data on each component used to achieve required power factor correction.

4. Data to enable calculation of motor load at design duty.

5. Value of Full Load Amperes (FLA) with correction capacitance provided and connected .

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with NFPA 70.

1.6 COORDINATION

A. Coordinate features of motors, installed units, and accessory devices and features that comply with the following:

1. Motor controllers.

2. Designed and labeled for use with variable frequency controllers, and suitable for use throughout speed range without overheating.

3. Matched to torque and horsepower requirements of the load, including drive loss.

4. Matched to ratings and characteristics of supply circuit and required control sequence.

B. Coordinate motor support with requirements for driven load; access for maintenance and motor replacement; installation of accessories, belts, belt guards; and adjustment of sliding rails for belt tensioning.

C. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

PART 2 - PRODUCTS

2.1 MOTOR REQUIREMENTS

A. Motor requirements apply to factory-installed motors except as follows:

1. Different ratings, performance, or characteristics for motor are specified in another Section.

2. Motorized-equipment manufacturer requires ratings, performance, or characteristics, other than those specified in this Section, to meet performance specified.

3. Comply with NEMA MG 1 unless otherwise indicated.

B. Provide motors as manufactured by US Motor, Baldor, Marathon Electric, or Lincoln.

2.2 MOTOR CHARACTERISTICS

A. Motors 1/2 HP and Larger: Three phase.

B. Motors Smaller Than 1/2 HP: Single phase.

C. Frequency Rating: 60 Hz.

D. Voltage Rating: NEMA standard voltage selected to operate on nominal circuit voltage to which motor is connected.

E. Service Factor: 1.15 for open drip proof motors; 1.0 for totally enclosed motors.

F. Duty: Continuous duty at 115 percent of rated capacity; base temperature rise on ambient temperature of 122 deg F and at altitude of 3300 feet above sea level.

G. 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.

H. Enclosure: Open drip proof, unless specified otherwise.

I. Speed: 1750 RPM, unless specified or scheduled otherwise.

J. Noise: Comply with maximum recommended IEC Standards (Tables B and C), and NEMA limits based on motor frame size, speed, and enclosure type, except maximum overall sound pressure levels shall not exceed 90 dBA as measured 3 feet from motor, and throughout its operating range from no load to full nameplate rating, and 15% speed to maximum speed to comply with CFR Title 41, Part 50-204.10.

2.3 POLYPHASE MOTORS

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

B. Efficiency: Premium, as defined in NEMA MG 1.

C. Stator: Copper windings, unless otherwise indicated.

D. Rotor: Squirrel cage, unless otherwise indicated.

E. Bearings: Double-shielded, prelubricated ball bearings suitable for radial and thrust loading.

F. Temperature Rise: Match insulation rating, unless otherwise indicated.

G. Insulation: Class F, unless otherwise indicated.

H. Code Letter Designation:

1. Motors Smaller Than 15 HP: Manufacturer's standard starting characteristic.

I. Enclosure: Cast iron or rolled steel.

1. Finish: Enamel.

2.4 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

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

B. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.

1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
2. Temperature Rise: Matched to rating for Class B insulation.
3. Insulation: Class F.
4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.
5. Shaft: Carbon steel.
6. Shaft Grounding: Provide shaft grounding brush equal to Aegis SGR™ Conductive Microfiber™ on drive end (between motor and shaft coupling to driven equipment).

C. Source Quality Control for Field-Installed Motors: Perform the following tests on each motor according to NEMA MG 1:

1. Measure winding resistance.
2. Read no-load current and speed at rated voltage and frequency.
3. Measure locked rotor current at rated frequency.
4. Perform high-potential test.

2.5 SINGLE-PHASE MOTORS

A. Type: One of the following, to suit starting torque and requirements of specific motor application:

1. Permanent-split capacitor.

2. Electronically commutated.

3. Split-phase start, capacitor run.

4. Capacitor start, capacitor run.

B. Shaded-Pole Motors: For motors 1/20 hp and smaller only.

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

D. Bearings: Ball type for belt-connected motors and other motors with high radial forces on motor shaft; sealed, prelubricated-sleeve type for other single-phase motors.

2.6 ELECTRONICALLY COMMUTATED MOTORS (ECM)

A. Description: Variable-speed, direct current (DC), brushless motors, with integral controller that operates the wound stator and senses rotor position to electronically commutate the stator.

1. Phase: Single or polyphase, as indicated on drawings.

2. Rotation: Synchronous, designed to overcome reverse rotation.

3. Rotor: Permanent magnet, with zero losses.

4. Ramping: Soft-start and soft speed change.

5. Mounting: Horizontal or vertical shaft.

6. Bearings: Ball type, permanently lubricated.

7. Efficiency: Higher than specified for AC motors.

8. Controller: Pulse width modulation type, factory installed, preset to scheduled flow.

a. Input Current: Alternating Current.

b. Output Current: Direct current.

c. Harmonic Filtration: Inductors.

d. Field adjustment of motor speed set point via the following:

1) Manual adjustment.
2) Remote 0-10 volt dc signal from BAS,
3) Remote Start/Stop Signal: Binary, from BAS

PART 3 - EXECUTION

3.1 COMMISSIONING

A. Most of the mechanical systems are included in the Commissioning Program. Refer to the following specification sections for requirements associated with Commissioning:

1. Section 019113 “General Commissioning Requirements”.

END OF SECTION

SECTION 230519 - METERS AND GAGES FOR MECHANICAL 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. This Section includes the following meters and gages for mechanical systems:

1. Thermometers.

2. Gages.

3. Test plugs.

B. Related Sections include the following:

1. Section 230900 "Instrumentation and Control for HVAC" for hydronic service flow meters inside the building.

2. Most of the mechanical systems are included in the Commissioning Program. Refer to the following specification sections for requirements associated with Commissioning:

a. Section 019113 “General Commissioning Requirements”.

1.3 DEFINITIONS

A. CR: Chlorosulfonated polyethylene synthetic rubber.

B. EPDM: Ethylene-propylene-diene terpolymer rubber.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated; include performance curves.

B. Shop Drawings: Schedule for thermometers and gages indicating manufacturer's number, scale range, and location for each.

C. Product Certificates: For each type of thermometer and gage signed by product manufacturer.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

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

2.2 REMOTE-MOUNTING, VAPOR-ACTUATED DIAL THERMOMETERS

A. Manufacturers:

1. Ashcroft Commercial Instrument Operations; Dresser Industries; Instrument Div.

2. Marsh Bellofram.

3. Trerice, H. O. Co.

4. Weiss Instruments, Inc.

5. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.

B. Case: Dry type, cast aluminum, 4-1/2-inch diameter with holes for panel mounting.

C. Element: Silicone damped bourdon tube.

D. Movement: Mechanical, connecting element and pointer.

E. Dial: Satin-faced, non-reflective aluminum with permanently etched scale markings.

F. Pointer: Red or other dark-color metal.

G. Window: Glass.

H. Ring: Aluminum.

I. Connector: Bottom or back union type, to suit application.

J. Thermal System: Gas/activated carbon filled bulb in copper-plated steel, aluminum, brass, or stainless steel stem for thermowell installation and of length to suit installation.

K. Accuracy: Plus or minus 1 percent of full range.

2.3 DIRECT MOUNTING DIGITAL THERMOMETERS

A. Manufacturers:

1. Ashcroft Commercial Instrument Operations; Dresser Industries; Instrument Div.

2. Marsh Bellofram.

3. Trerice, H. O. Co.

4. Weiss Instruments, Inc.

5. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.

B. Description: Direct-mounting, light-powered digital thermometers.

C. Case: Cast aluminum with cured epoxy coating, 7-inch.

D. Display: 9/16” LCD display lights, switchable between Fahrenheit and Celsius, minimum and maximum readins with reset. Resolution 0.1 deg with full 4-digt display and an update interval of 10 seconds.

E. Power Source: Minimum 10 Lux (one foot candle) ambient light source; no external power or batteries shall be required.

F. Connector: Adjustable angle type.

G. Stem: Metal, for thermowell installation and of length to suit installation.

H. Accuracy: Plus or minus 1 percent of full range.

2.4 THERMOWELLS

A. Manufacturers:

1. Ashcroft Commercial Instrument Operations; Dresser Industries; Instrument Div.

2. Marsh Bellofram.

3. Miljoco.

4. Trerice, H. O. Co.

5. Weiss Instruments, Inc.

6. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.

B. Description: Pressure-tight, socket-type metal fitting made for insertion into piping and of type, diameter, and length required to hold thermometer.

1. Extension Neck: For insulated piping.

2.5 PRESSURE GAGES

A. Manufacturers:

1. Ashcroft Commercial Instrument Operations; Dresser Industries; Instrument Div.
2. Marsh Bellofram.
3. Miljoco.
4. Trerice, H. O. Co.
5. Weiss Instruments, Inc.
6. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.

B. Direct-Mounting, Dial-Type Pressure Gages: Indicating-dial type complying with ASME B40.100.

1. Case: Dry- or Liquid-filled (as indicated) type, fiberglass reinforced polypropylene, solid front with blowout back, 4-1/2-inch diameter.
2. Pressure-Element Assembly: Bronze or stainless steel bourdon tube, unless otherwise indicated.
3. Pressure Connection: Brass or 316 stainless steel, NPS 1/4, bottom-outlet.
4. Movement: Mechanical, with stainless steel link to pressure element and connection to pointer.
5. Dial: White satin-faced, non-reflective aluminum with permanently etched scale markings.
6. Pointer: Black or other dark-color metal.
7. Window: Acrylic.
8. Ring: Threaded fiberglass reinforced polypropylene.
9. Accuracy: Grade 1A, plus or minus 1 percent of full range.
10. Vacuum-Pressure Range: 30-in. Hg of vacuum to 15 psig of pressure.
11. Range for Fluids under Pressure: Two times operating pressure.

C. Remote-Mounting, Dial-Type Pressure Gages: ASME B40.100, indicating-dial type.

1. Case: Dry- or Liquid-filled type (as indicated), fiberglass reinforced polypropylene, 4-1/2-inch diameter with holes for panel mounting.

2. Pressure-Element Assembly: Bronze or stainless steel bourdon tube, unless otherwise indicated.

3. Pressure Connection: Brass or 316 stainless steel, NPS 1/4, bottom-outlet or back-outlet type, connected for easy reading.

4. Movement: Mechanical, with stainless steel link to pressure element and connection to pointer.

5. Dial: White satin-faced, non-reflective aluminum with permanently etched scale markings.

6. Pointer: Black or other dark-color metal.

7. Window: Acrylic.

8. Ring: Threaded fiberglass reinforced polypropylene.

9. Accuracy: Grade 1A, plus or minus 0.5 percent of full half range.

10. Vacuum-Pressure Range: 30-in. Hg of vacuum to 15 psig of pressure.

11. Range for Fluids under Pressure: Two times operating pressure.

D. Pressure-Gage Fittings:

1. Valves: NPS 1/4 ball type.

   a. General Service: Provide ball valve equal to ball shut-off valves specified for particular service in Section 230523 “General Duty Valves for Mechanical Piping.”

2. Snubbers: ASME B40.5, NPS 1/4 brass bushing with corrosion-resistant, porous-metal disc of material suitable for system fluid and working pressure.

2.6 TEST PLUGS

A. Manufacturers:

1. Flow Design, Inc.

2. Peterson Equipment Co., Inc.

3. Sisco Manufacturing Co.

4. Trerice, H. O. Co.

5. Watts Industries, Inc.; Water Products Div.

B. Description: Corrosion-resistant brass or stainless-steel body with core inserts and gasketed and threaded cap, with extended stem for units to be installed in insulated piping.

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

D. Core Inserts: One or two self-sealing rubber valves.

1. Insert material for air, water, oil, or gas service at 20 to 200 deg F shall be CR.

2. Insert material for air or water service at minus 30 to plus 275 deg F shall be EPDM.

E. Test Kit: Furnish two test kits containing one pressure gage and adaptor, two thermometer(s), and carrying case. Pressure gage, adapter probes, and thermometer sensing elements shall be of diameter to fit test plugs and of length to project into piping.

1. Pressure Gage: Small bourdon-tube insertion type with 2- to 3-inch- diameter dial and probe. Dial range shall be 0 to 200 psig.

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

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

4. Carrying case shall have formed instrument padding.

PART 3 - EXECUTION

3.1 THERMOMETER APPLICATIONS

A. Install remote-mounting, vapor-actuated dial thermometers where installed greater than 96 inches above floor.

B. Install direct mounting digital type thermometers where installed within 96 inches above floor.

C. Provide the following temperature ranges for thermometers, except digital type thermometers to have inherent range of -40 to 300 deg F:

1. Condenser Water: 0 to 200 deg F, with 2-degree scale divisions.

2. Air Ducts: Minus 40 to plus 110 deg F, with 2-degree scale divisions.

3. Domestic Hot Water and Tepid Water: 30 to 180 deg F, with 2-degree scale divisions.

4. Domestic Cold Water: 0 to 100 deg F, with 2-degree scale divisions.

3.2 GAGE APPLICATIONS

A. Install direct-mounting type pressure gages where installed within 84 inches of floor.

B. Install remote-mounting type pressure gages where installed greater than 84 inches above floor.

C. Install liquid-filled case type, except for steam services and gages mounted outdoors. Install dry case type for steam services and gages mounted outdoors.

D. Provide bronze pressure-element assembly and pressure connections for each pressure gage for fluids, except for steam services. Provide stainless steel pressure-element assembly and pressure connections for each pressure gage for steam services.

E. Provide the following pressure ranges for gages:

1. General: Normal pointer position in mid-span of gage range.

2. Condenser Water, General: 0 to 100 psig, with 2-psi scale divisions.

3. Domestic Hot Water and Tepid Water: 0 to 200 psi, with 2-psi divisions

4. Domestic Cold Water, Non-Potable Water, Treated Water and Tepid Water: 0 to 200 psig, with 2-psi scale divisions.

5. Storm Water Pumped Discharge, Sanitary Pump Discharge: 0 to 30 psi, with 1-psi scale divisions

6. Air-conditioning Condensate Pump Discharge: 0 to 100 psig, with 2-psi scale divisions.

3.3 INSTALLATIONS

A. Install direct-mounting thermometers and adjust vertical and tilted positions.

B. Install remote-mounting dial thermometers on panel, with tubing connecting panel and thermometer bulb supported to prevent kinks. Use minimum tubing length.

C. Install thermowells with socket extending a minimum of 2 inches into fluid and in vertical position in piping tees or threadolets where thermometers are indicated, and where required for ATC devices. Coordinate with Section 230900 “Instrumentation and Control for HVAC.”

1. Install heat conducting compound within thermowell.

D. Duct Thermometer Support Flanges: Install in wall of duct where duct thermometers are indicated. Attach to duct with screws.

E. Install direct-mounting pressure gages in piping tees or threadolets with pressure gage located on pipe at most readable position.

1. Install in weldolets for steam service.

F. Install remote-mounting pressure gages on panel.

G. Install ball-valve and snubber fitting in piping for each pressure gage for fluids (except steam); minimize length of piping nipples between gages and piping mains.

H. Install test plugs in piping tees or threadolets.

3.4 CONNECTIONS

A. Install meters and gages adjacent to machines and equipment to allow service and maintenance for meters, gages, machines, and equipment.

3.5 ADJUSTING

A. Calibrate meters according to manufacturer's written instructions, after installation.

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

3.6 COMMISSIONING

A. Most of the mechanical systems are included in the Commissioning Program. Refer to the following specification sections for requirements associated with Commissioning:

1. Section 019113 “General Commissioning Requirements”.

END OF SECTION

SECTION 230523 - GENERAL DUTY VALVES FOR MECHANICAL PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following general-duty valves:

1. Copper-alloy ball valves.

2. Swing check valves - bronze.

3. Bronze globe valves.

4. Cast-iron globe valves.

B. Related Sections include the following:

1. Section 23 05 53 “Identification for Mechanical" for valve tags and charts.

2. Section 23 09 00 "Instrumentation and Control for HVAC" for control valves and actuators.

3. Division 23 piping Sections for specialty valves applicable to those Sections only.

1.3 DEFINITIONS

A. The following are standard abbreviations for valves:

1. CWP: Cold working pressure.

2. EPDM: Ethylene-propylene-diene terpolymer rubber.

3. NBR: Acrylonitrile-butadiene rubber.

4. OS&Y: Outside screw and yoke

5. PTFE: Polytetrafluoroethylene plastic.

6. RF: Raised face.

7. SWP: Steam working pressure.

8. TFE: Tetrafluoroethylene plastic.

1.4 SUBMITTALS

A. Product Data: For each type of valve indicated. Include body, seating, and trim materials; valve design; pressure and temperature classifications; end connections; arrangement; actuators; dimensions; and required clearances. Include list indicating valve and its application. Include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories.

1.5 QUALITY ASSURANCE

A. ASME Compliance: ASME B31.9 for building services piping valves (remaining piping systems).

1. Exceptions: Domestic hot- and cold-water piping valves unless referenced.

B. ASME Compliance for Ferrous Valves: ASME B16.10 and ASME B16.34 for dimension and design criteria.

C. NSF Compliance: NSF 61 for valve materials for potable-water service.

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 gate and globe valves closed to prevent rattling.

4. Set ball 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 MANUFACTURERS

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

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

2.2 VALVES, GENERAL

A. Refer to Part 3 "Valve Applications" Article for applications of valves.

B. Bronze Valves: Water Service - NPS 2 and smaller with threaded ends, unless otherwise indicated.

C. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

D. Valve Sizes: Same as upstream pipe, unless otherwise indicated.

E. Valve Actuators:

1. Chainwheel: For attachment to valves, of size and mounting height, as indicated in the "Valve Installation" Article in Part 3.

2. Gear Drive with Adjustable Memory Stop: For quarter-turn valves NPS 6” and larger, unless otherwise noted.

3. Handwheel: For valves other than quarter-turn types. Valve hand wheels shall be cast.

4. Lever Handle with Adjustable Memory Stop: For quarter-turn valves NPS 5 and smaller.

5. Gear operators shall be packed with high temperature grease.

F. Extended Valve Stems: On insulated valves; minimum 2” extension.

G. Valve Flanges: ASME B16.1 for cast-iron valves, ASME B16.5 for steel valves, and ASME B16.24 for bronze valves.

H. Threaded: With threads according to ASME B1.20.1

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

J. Valve Manufacturer: Each valve type in same system shall be by a single manufacturer and same model.

K. Control Valves: Refer to Section 23 09 00 "Instrumentation and Control for HVAC" for control valves and actuators.

2.3 COPPER-ALLOY BALL VALVES

A. Manufacturers:

1. Two-Piece, Copper-Alloy Ball Valves:

    a. Conbraco Industries, Inc.; Apollo Div.

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

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

    d. Jamesbury, Inc.

    e. Milwaukee Valve Company.

B. Copper-Alloy Ball Valves, General: MSS SP-110.

C. Two-Piece, Copper-Alloy Ball Valves: Bronze body with regular-port, solid stainless steel tunnel drilled ball; RPTFE 15% glass-filled seats; 25% glass-filled thrust washer; PTFE packing; brass hexagonal threaded packing nut; and 600-psig minimum CWP rating and blowout-proof stainless steel stem.

2.4 SWING CHECK VALVES - BRONZE

A. Manufacturers:

1. Type 3, Bronze, Horizontal Swing Check Valves with Metal Disc:

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

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

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

d. Grinnell Corporation.

e. Milwaukee Valve Company

B. Bronze Check Valves, General: MSS SP-80.

C. Type 3, Class 125, Bronze, Horizontal Swing Check Valves: Bronze body with bronze disc, plug, and 5 degree integral seat; stainless steel retaining ring and hinge pin.

2.5 GRAY-IRON SWING CHECK VALVES

A. Manufacturers:

1. Type I, Gray-Iron Swing Check Valves with Metal Seats:

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

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

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

d. Grinnell Corporation.

e. Milwaukee Valve Company

B. Gray-Iron Swing Check Valves, General: MSS SP-71..

C. Type I, Class 125, gray-iron, swing check valves with metal seats.

2.6 BRONZE GLOBE VALVES

A. Manufacturers:

1. Type 2, Bronze Globe Valves with Nonmetallic Disc:

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

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

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

d. Grinnell Corporation.

e. Milwaukee Valve Company.

B. Bronze Globe Valves, General: MSS SP-80, with ferrous-alloy handwheel.

C. Type 2, Class 150, Bronze Globe Valves: Bronze body with hexagon gland follower, rising stem, minimum four-sided stem to hand-wheel connection with self-locking nut, disc union-ring bonnet, integral seat; aramid fiber and graphite packing with a neoprene binder for service up to 550 deg F.

2.7 CAST-IRON GLOBE VALVES

A. Manufacturers:

1. Type I, Cast-Iron Globe Valves with Metal Seats:

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

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

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

   d. Grinnell Corporation.

   e. Milwaukee Valve Company.

B. Cast-Iron Globe Valves, General: MSS SP-85.

C. Type I, Class 125, Cast-Iron Globe Valves: Gray-iron body with hexagon gland follower, rising stem, bolted bonnet, brass stem and packing gland, minimum four-sided stem to hand-wheel connection with self-locking nut, bronze seats; aramid fiber and graphite packing with neoprene binder for service up to 550 deg F.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine piping system for compliance with requirements for installation tolerances and other conditions affecting performance.

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

B. 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.

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

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

E. 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.

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

3.2 VALVE APPLICATIONS

A. Refer to piping Sections for specific valve applications. If valve applications are not indicated, use the following:

1. Shutoff Service: Ball, butterfly, or gate valves for water service.

2. Throttling Service: Ball, butterfly, or globe valves for water service.

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

C. Condenser Water Piping: Use the following types of valves:

1. Ball Valves, NPS 2 and Smaller: Two -piece, 600-psig CWP rating, copper alloy.

2. Swing Check Valves, NPS 2 and Smaller: Type 3, Class 125, bronze.

3. Globe Valves, NPS 2 and Smaller: Type 2, Class 150, bronze.

D. Non-Potable and Domestic Water Piping: Use the following types of valves:

1. Ball Valves, NPS 2 and Smaller: Two-piece, 600-psig CWP rating, copper alloy.

2. Swing Check Valves, NPS 2 and Smaller: Type 3, Class 125, bronze.

3. Globe Valves, NPS 2 and Smaller: Type 2, Class 150, bronze.

E. Select valves, except wafer and flangeless types, with the following end connections:

1. For Copper Tubing, NPS 2 and Smaller: Solder-joint or threaded ends, except provide valves with threaded ends for condenser water.

2. For Steel Piping, NPS 2 and Smaller: Threaded ends.

3. For Grooved-End, Steel Piping: Flanged ends.

3.3 VALVE INSTALLATION

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install valves in strict accordance with recognized industry standards, valve manufacturer's recommendations, and the general guidelines noted herein.

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

D. Locate valves for easy access, smooth and easy actuator operation, and packing maintenance; provide separate support where necessary.

E. When placing valves between welding type flanges, carefully position the valve between the flanges with the flange bores and valve body properly aligned. Span the valve body with the flange bolts and properly align the assembly with the pipe. Tack weld the flanges to the pipe. When tack welding is complete, remove the flange bolts and the valve from the pipe flanges prior to completing the welding of the pipe flanges. After completing the welding of the pipe flanges, let the pipe and flanges cool to ambient temperature, before installing the valve between the pipe flanges.

F. When placing threaded bodied valves in pipelines, note the internal length of threads in the valve ends and proximity of valve internal seat or wall to determine how far pipe should be threaded into the valve. Align threads at point of assembly. Apply appropriate thread sealants to the external pipe threads. Assemble joint, wrench tight with the wrench on the valve end (not valve body) into which the pipe is being threaded.

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

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

I. Install butterfly valves between weld neck companion flanges of the same ANSI class as the valve.

J. Install chainwheel operators on valves NPS 2-1/2 and larger and more than 108 inches above floor or grade. Extend chains to 60 inches above finished floor or grade elevation.

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

1. Swing Check Valves: In horizontal position with hinge pin level.

3.4 JOINT CONSTRUCTION

A. Refer to Section 23 05 00 "Common Work Results for Mechanical" for basic piping joint construction.

3.5 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.

END OF SECTION

SECTION 230529 - HANGERS AND SUPPORTS FOR MECHANICAL 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. This Section includes the following hangers and supports for mechanical system piping and equipment:
   1. Steel pipe hangers and supports.
   2. Trapeze pipe hangers.
   3. Metal framing systems.
   4. Thermal-hanger shield inserts.
   5. Fastener systems.
   6. Pipe stands.
   7. Pipe positioning systems.
   8. Equipment supports.

B. Related Sections include the following:
   1. Division 05 Sections for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
   2. Section 23 05 48 "Mechanical Vibration Control" for vibration isolation devices and additional hanger and support requirements.
   3. Section 23 31 13 "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 PERFORMANCE REQUIREMENTS

A. Design supports for multiple pipes capable of supporting combined weight of supported systems, system contents, and test water.

B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

1.5 SUBMITTALS

A. Product Data: For the following:
   1. Steel pipe hangers and supports.
   2. Thermal-hanger shield inserts.
   3. Powder-actuated fastener systems.
   4. Pipe positioning systems.

B. 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.

C. Welding certificates.

1.6 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to the following:
   1. AWS D1.1, "Structural Welding Code--Steel."
   2. AWS D1.3, "Structural Welding Code--Sheet Steel."
   3. AWS D1.4, "Structural Welding Code--Reinforcing Steel."
   4. ASME Boiler and Pressure Vessel Code: Section IX.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles below where titles below introduce lists, the following requirements apply to product selection:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 STEEL 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. Grinnell Corp.
   3. National Pipe Hanger Corporation.
   4. Piping Technology & Products, Inc.

C. Galvanized, Metallic Coatings: Pregalvanized or hot dipped.

D. Nonmetallic Coatings: Plastic coating, jacket, or liner.

2.3 TRAPEZE PIPE HANGERS

A. Description: MSS SP-69, Type 59, shop- or field-fabricated pipe-support assembly made from structural-steel shapes with MSS SP-58 hanger rods, nuts, saddles, and U-bolts.

2.4 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. Power-Strut Div.; Tyco International, Ltd.
3. Thomas & Betts Corporation.
4. Unistrut Corp.; Tyco International, Ltd.

C. Coatings: Manufacturer's standard finish, unless bare metal surfaces are indicated.

D. Nonmetallic Coatings: Plastic coating, jacket, or liner.

2.5 THERMAL-HANGER SHIELD INSERTS

A. Description: 100-psig- minimum, compressive-strength insulation insert encased in sheet metal shield.

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: Water-repellent treated, ASTM C 533, Type I calcium silicate or ASTM C 552, Type II cellular glass with vapor barrier.

D. Insulation-Insert Material for Hot Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate or ASTM C 552, Type II cellular glass.

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.

2.6 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.
   1. Manufacturers:
      a. Hilti, Inc.
      b. ITW Ramset/Red Head.
      c. Masterset Fastening Systems, Inc.

B. Mechanical-Expansion Anchors: Insert-wedge-type zinc-coated 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. Manufacturers:
      a. B-Line Systems, Inc.; a division of Cooper Industries.
      b. Hilti, Inc.
      c. ITW Ramset/Red Head.

2.7 PIPE STAND FABRICATION

A. Pipe Stands, General: Shop or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping and piping routed at grade.

B. 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.
   1. Manufacturers:
      a. ERICO/Michigan Hanger Co.
      b. MIRO Industries.

C. Low-Type, Single-Pipe Stand: One-piece plastic base unit with plastic roller, for roof installation without membrane penetration.
   1. Manufacturers:
      a. MIRO Industries.

D. High-Type, Single-Pipe Stand: Assembly of base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
   1. Manufacturers:
      a. ERICO/Michigan Hanger Co.
      b. MIRO Industries.
      c. Portable Pipe Hangers.
   2. Base: Stainless steel.
   3. Vertical Members: Two or more cadmium-plated-steel or stainless-steel, continuous-thread rods.

4. Horizontal Member: Cadmium-plated-steel or stainless-steel rod with plastic or stainless-steel, roller-type pipe support.

E. High-Type, Multiple-Pipe Stand: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.
  1. Manufacturers:
     a. Portable Pipe Hangers.
  2. Bases: One or more plastic.
  3. Vertical Members: Two or more protective-coated-steel channels.
  4. Horizontal Member: Protective-coated-steel channel.
  5. Pipe Supports: Galvanized-steel, clevis-type pipe hangers.

2.8 PIPE POSITIONING SYSTEMS

A. Description: IAPMO PS 42, system of metal brackets, clips, and straps for positioning piping in pipe spaces for plumbing fixtures for commercial applications.

B. Manufacturers:
  1. C & S Mfg. Corp.
  2. HOLDRITE Corp.; Hubbard Enterprises.
  3. Samco Stamping, Inc.

2.9 EQUIPMENT SUPPORTS

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

2.10 MISCELLANEOUS MATERIALS

A. Structural Steel: ASTM A 36/A 36M, steel plates, shapes, and bars with primer/paint or galvanized coatings matching adjoining or similar components indicated in Division 5 .

B. Grout: Refer to Section 23 05 00 “Common Work Results for Mechanical.”

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT APPLICATIONS

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

B. Comply with MSS SP-69 for pipe hanger selections and applications that are not specified in piping system Sections.

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

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

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

F. Size hangers and supports to match OD of pipe insulation.

G. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated stationary pipes, NPS 1/2 to NPS 30.
2. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes, NPS 3/4 to NPS 24, requiring clamp flexibility and up to 4 inches of insulation.
3. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes, NPS 1/2 to NPS 24, if little or no insulation is required.
4. Pipe Hangers (MSS Type 5): For suspension of pipes, NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
5. Adjustable Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated stationary pipes, NPS 3/4 to NPS 8.
6. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8.
7. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8.
8. Adjustable Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 2.
9. Split Pipe-Ring with or without Turnbuckle-Adjustment Hangers (MSS Type 11): For suspension of noninsulated stationary pipes, NPS 3/8 to NPS 8.
10. Extension Hinged or 2-Bolt Split Pipe Clamps (MSS Type 12): For suspension of nonin sulated stationary pipes, NPS 3/8 to NPS 3.
11. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
12. Single Pipe Rolls (MSS Type 41): For suspension of pipes, NPS 1 to NPS 30, from 2 rods if longitudinal movement caused by expansion and contraction might occur.

H. 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 20.
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers, NPS 3/4 to NPS 20, if longer ends are required for riser clamps.

I. 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.

J. 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.

K. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Hot and cold insulated piping services: Thermal-Hanger Shield Inserts.

L. 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 absorb 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 absorb 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 absorb 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 load-adjustment capability. These supports include the following types:
   a. Horizontal (MSS Type 54): Mounted horizontally.
   b. Vertical (MSS Type 55): Mounted vertically.
   c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.

M. Comply with MSS SP-69 for trapeze pipe hanger selections and applications that are not specified in piping system Sections.

N. Comply with MFMA-102 for metal framing system selections and applications that are not specified in piping system Sections.

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

P. Use pipe positioning systems in pipe spaces behind plumbing fixtures to support supply and waste piping for plumbing fixtures.

3.2 HANGER AND SUPPORT INSTALLATION

A. Steel Pipe Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.

B. Trapeze Pipe Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping and support together on field-fabricated trapeze pipe hangers.
   1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified above for individual pipe hangers.
   2. Field fabricate from ASTM A 36/A 36M, steel shapes selected for loads being supported. Weld steel according to AWS D1.1.

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

D. Thermal-Hanger Shield Installation: Install in pipe hanger and provide sheet metal shield for insulated piping (cold services).

E. Fastener System Installation:

1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches 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-Mounting Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
2. Curb-Mounting-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. Refer to Section 07 72 00 "Roof Accessories" for curbs.

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

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

L. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and so maximum pipe deflections allowed by ASME B31.1 (for power piping) and ASME B31.9 (for building services piping) are not exceeded.

M. Insulated Piping:
1. Install thermal-hanger shield inserts at each support location for hot and cold services.
2. Sheet Metal Shield Dimensions for Pipe: Not less than the following:
   a. NPS 1/4 to NPS 3-1/2: 12 inches long.
3. 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 smooth bearing surface.

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 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 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. Touch Up: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Division 9 painting sections.

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

END OF SECTION

SECTION 230548 – MECHANICAL VIBRATION CONTROL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Provide complete noise control systems as shown or specified and in accordance with the requirements of the Contract Documents. System shall be complete with:
   1. Vibration Isolators.
   2. Fan and Duct System Plenums.
   3. Suitable Penetrations Through Walls and Slabs

B. Related Sections
   1. Section 07 9100 - Joint Protection: Product requirements for joint sealers specified for placement by this section.
   2. Section 23 0529 - Hangers and Supports for HVAC Piping and Equipment: Product requirements for pipe hangers and supports.
   3. Section 23 0593 - Testing, Adjusting, and Balancing for HVAC: Requirements for sound and vibration measurements performed independent of this section.
   4. Section 23 2123 – Hydronic Pumps: Product Requirements for mounting of pumps.
   5. Section 23 3300 - Air Duct Accessories: Product requirements for both solid and flexible duct connectors for duct silencers specified for placement by this section.
   6. Section 23 3113 – Metal Ducts: Product Requirements for lined ductwork.
   7. Section 23 8127 –Air Conditioning Units and Drycoolers: Requirements for mounting Air Conditioning Units and drycoolers.

1.3 REFERENCES

A. Air Movement and Control Association International, Inc.:
   1. AMCA 300 - Reverberant Room Method for Sound Testing of Fans.

B. American National Standards Institute:
   1. ANSI S1.4 - Sound Level Meters.
   2. ANSI S1.8 - Reference Quantities for Acoustical Levels.
   3. ANSI S1.13 - Methods for the Measurement of Sound Pressure Levels in Air.
   4. ANSI S12.36 - Survey Methods for the Determination of Sound Power Levels of Noise Sources.

C. Air-Conditioning and Refrigeration Institute:

1. ARI 575 - Method of Measuring Machinery Sound within Equipment Space.

D. American Society of Heating, Refrigerating and Air-Conditioning Engineers:
   1. ASHRAE 68 - Laboratory Method of Testing In-Duct Sound Power Measurement Procedure for Fans.
   2. ASHRAE Handbook - 2007 HVAC Applications Chapter 47.

E. ASTM International:
   1. ASTM E90 - Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements.
   2. ASTM E477 - Standard Test Method for Measuring Acoustical and Airflow Performance of Duct Liner Materials and Prefabricated Silencers.
   3. ASTM E596 - Standard Test Method for Laboratory Measurement of the Noise Reduction of Sound-Isolating Enclosures.

F. Sheet Metal and Air Conditioning Contractors' National Association:
   1. SMACNA - HVAC Duct Construction Standard - Metal and Flexible.
   2. SMACNA - Restraint Manual: Guidelines for Mechanical Systems.

1.4 PERFORMANCE REQUIREMENTS

A. Provide vibration isolation on motor driven equipment, plus connected piping and ductwork as specified in this section and as scheduled within the Drawings.

B. The Contractor shall be responsible for verifying the completeness of the isolation installation and the overall suitability of the equipment to meet the intent of this Specification.

C. Performance or waiving of inspection, testing, or surveillance for any portion of the Work shall not relieve the Contractor of the responsibility to conform strictly to the Contract Documents. The Contractor shall not construe performance or waiving of inspection, testing or surveillance by the Owner or Architect to relieve the Contractor from total responsibility to perform in strict accordance with the Contract Documents.

D. Provide structural work and restraints for pipes and ducts shall be as per the SMACNA Guidelines for Restraint of Mechanical Systems.

E. Determine system weight, load reactions, center of gravity, building capacity to accept loads, and support mechanisms. Then restraints design to meet the criteria established in the Florida Code of Regulations.

F. Provide calculations by a Professional Structural Engineer, licensed in the state of Florida substantiating that all supports and anchors meet the load requirements and can accept the generated forces without failure.

G. Provide building structural engineer with required loads and forces required to support and restrain installation.

H. Provide isolation and anchorage equipment, including anchors. See Section 23 0529 for anchorage criteria.

I. Vibration isolators shall operate in the linear portion of their load versus deflection curve. The curve shall be linear over a deflection range of not less than 50% above the design deflection. The ratio of lateral to vertical stiffness shall be neither less than 0.8 nor greater than 1.5.

J. Vibration isolators shall be non-resonant with equipment forcing frequencies or support structure natural frequencies.

K. Provide minimum static deflection of isolators for equipment as indicated on the mechanical schedules.

L. Use concrete inertia bases for fans and base mounted pumps as scheduled in the Drawings.

M. Maintain sound level of spaces at levels not to exceed those listed below by utilizing acoustical devices.

1.5 MANUFACTURER'S RESPONSIBILITIES

A. Manufacturer of vibration isolation equipment shall have the following responsibilities:
   1. Provide piping and equipment isolation systems as scheduled or specified.
   2. Guarantee specified isolation system deflection under actual load conditions within 10% of specified static deflections.
   3. Provide installation instructions, drawings and field supervision to ensure proper installation and performance.
   4. Determination of all mounting sizes and complete instructions for installation of all products supplied.
   5. The vibration isolator vendor shall ensure that all equipment to be isolated has sufficient support structure to distribute equipment loads onto isolators. Vibration Isolation Manufacturer or Vendor shall be responsible for identifying any additional support structure required within initial product submittal.

1.6 SUBMITTALS

A. The Contractor shall submit at the time of bidding the names and qualifications of the noise and vibration control vendor(s) and manufacturer(s). If this company has not been pre-approved within this section, the initial product submittal shall be accompanied by a complete catalog of the proposed vendor’s (manufacturer’s) products and samples of each proposed vibration isolator.

B. Contractor shall submit the design sound power level of each air moving device (including fans and package air handlers) as described in the Contract Documents. If the sound power generated by any submitted device exceeds the specified sound power levels for the equipment, the contractor shall include proposals as required to compensate for the additional noise. All proposals shall be subject to review and approval by Owner, Architect, and Acoustics Consultant.

C. If the standard sizes of silencers offered by the silencer manufacturer or vendor do not provide attenuation equal to or greater than the specified insertion loss in each octave band 1 through 6, then at the time of bidding the manufacturer/vendor making the submission shall note all such discrepancies and provide alternative proposals and pricing to make up the discrepancies. The controlling requirements are the insertion loss, pressure drop and self-noise.

D. Contractor shall submit fully coordinated shop drawings for all vibration and noise control equipment. These submittals shall state the acoustical performance of the products as described below.

E. Sheet Metal: Coordinated shop drawings at 1:100 minimum scale shall be submitted for review and approval to indicate the following:
   1. Length, width, height, and elevation of bottom of each duct segment.
   2. Sheet metal gauge.
   3. Location of duct silencers, fire dampers, and balancing dampers.
   4. Transition segments marked with entrance and exit sizes, as well as length and elevation. Markings should indicate which sides are held level, and which ones slope.
   5. If a duct segment is offset in the horizontal or vertical direction, this information must be noted.
   6. Duct lining thickness.
   7. Any restraints or points of conflict due to existing conditions or planned piping, conduit, structure, or finish which will interfere with the installation of the ductwork.

F. Air moving devices (Supply, return and exhaust fans, package AHU's): Submit sound power levels in octave bands from 63 Hz through 8000 Hz inclusive for the operating conditions specified. Data shall be obtained in accordance with AMCA 300-85. If fans are variable speed, provide sound power level data for maximum rpm and also at 80% and 60% of maximum rpm. Provide discharge, inlet and case-radiated sound power data for all fans.
   1. Submit for each fan a performance curve showing the operating point for which the acoustical data has been provided.

G. Silencers: Submit test data from an independent laboratory showing the insertion loss and airflow-regenerated noise of the specified silencers in octave bands from 63 Hz to 8000 Hz, measured in accordance with ASTM E477-73. Pressure drop ratings shall be measured for the same silencer tested for acoustical performance; the data shall be submitted with the acoustical performance data. The insertion loss of the silencers shall be measured and reported in octave band or 1/3 octave bands.

H. Isolators: Submittals shall include drawings prepared by the isolation materials manufacturer showing the construction of the isolation devices to be used, including specific selection of isolators for the equipment to be furnished for this project.
   1. Submittal of vibration isolation system schedule indicating the following:
      a. Manufacturer, type, model number, size
      b. Height when uncompressed and static deflection of each isolation element
      c. Spring constant of each isolation element
      d. Estimated imposed load on each isolation element
      e. Spring o.d., free operating, and solid heights
      f. Design of supplementary bases.
      g. Seismic restraints.
      h. Layout of isolator hangers, mounts, and other elements shown on an outline of the isolated equipment, including complete details of attachment to load-bearing structure or supplementary framing.
      i. Piping isolators shown and identified on piping layout drawings.
      j. All concrete foundations and supports (and required reinforcing and forms) will be furnished and installed by another trade. However, this trade shall furnish shop drawings showing adequate concrete reinforcing steel details and templates for all concrete foundations and supports, and all required hanger bolts and other appurtenances necessary for the proper installation of his equipment. Although another trade will complete all concrete work, all such work shall be shown in detail on the shop drawings, prepared by this trade which drawings shall be submitted showing the complete details of all foundations including necessary concrete and steel work, vibration isolation devices, etc.

1.7 CLOSEOUT SUBMITTALS

A. Execution and Closeout Requirements: (from Section 01 XX XX): Closeout Procedures.

B. Project Record Documents: Record actual locations of equipment and noise reducing treatments defined in this section. Record actual locations of hangers including attachment points, loads and static deflection at time of building handover.

1.8 QUALITY ASSURANCE

A. Perform Work in accordance with AMCA 300, ANSI S1.13, ARI 575, ANSI S12.36, and standards and recommendations of ASHRAE 68.

B. It is the objective of this Specification to provide for the control of noise and vibration due to the operation of machinery or equipment, and/or due to interconnected piping, ductwork or conduit.

C. The installation of all noise and vibration control systems shall be under the supervision of the manufacturer's representative.

D. All vibration isolation equipment and materials shall be provided by a single manufacturer. The following manufacturers are pre-approved based on the quality of previous work. The Acoustics Consultant and Architect must approve any alternates. All provided equipment and materials must be in compliance with the specified design and performance requirements:
    1. Mason Industries, Inc., Hauppauge, New York
    2. Vibration Mountings and Controls, Bloomingdale, New Jersey
    3. Kinetics Noise Control, Dublin, Ohio

E. All prefabricated duct silencers shall be furnished by a single manufacturer with a minimum five years experience. The following manufacturers are pre-approved based on the quality of their products. The Acoustics Consultant and Architect must approve any alternates. All provided equipment must be in compliance with the specified design and performance requirements:
    1. Industrial Acoustics Company, Bronx, New York
    2. Vibro-Acoustics, Scarborough, Ontario
    3. AeroAcoustic Corporation, Roselle, New Jersey
    4. Price Industries, Suwanee, Georgia

F. The following duct liner manufacturers are pre-approved based on the quality of their products. The Acoustics Consultant and Architect must approve any alternates. All provided equipment must be in compliance with the specified design and performance requirements:
    1. Certainteed
    2. Owens-Corning
    3. Knauf Insulation
    4. Johns-Manville

1.9 QUALIFICATIONS

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

B. Installer: Company specializing in performing Work of this section with minimum three years experience.

C. Design application of snubbers, anchorage, and restraint under direct supervision of Professional Engineer experienced in design of this Work and licensed in State of Florida.

1.10 PRE-INSTALLATION MEETINGS

A. Section 01 XX XX - Administrative Requirements: Pre-installation meeting.

B. Convene minimum one week prior to commencing work of this section.

1.11 FIELD MEASUREMENTS

A. Verify field measurements prior to fabrication.

1.12 WARRANTY

A. Section 01000 – General Conditions: Warranty.

B. Furnish minimum one year manufacturer warranty, commencing at General Contractor Date of Substantial Completion, for vibration isolation components; or furnish warranty as specified in the agreement between the owner and contractor, whichever is greater.

PART 2 - PRODUCTS

2.1 GENERAL

A. All equipment provided for vibration isolation or noise control shall be new and manufactured specifically for the purpose intended.

2.2 INTERNAL ACOUSTICAL DUCT LINING

A. Refer to Section 233113 for duct lining materials and additional requirements.

B. The following ductwork systems shall be internally lined:
   1. All ductwork specifically identified on mechanical drawings.

2.3 FOAM ROD

A. Foam backer rod shall be closed cell polyethylene suitable for use as a backing for non-hardening sealant.

2.4 NON-HARDENING SEALANT

A. Sealant for penetrations shall be non-hardening polysulphide type as specified in Division 7.

B. Permanently flexible, approved firestop putty, specified in Division 7, may be used in lieu of the sealant on foam rod in noise critical walls that are also fire rated.

2.5 PACKING MATERIAL FOR PENETRATIONS

A. Mineral fiber; non-combustible; resistant to water, mildew and vermin. USG Thermafiber, 2.5 pcf density, or equivalent product by Roxul, Inc.

2.6 VIBRATION ISOLATORS

A. GENERAL
   1. The static deflection of isolators shall be as given in the equipment schedule and specified below. The isolator schedule shall take precedence.
   2. Vibration isolator sizes and layout shall be determined by the vibration isolator supplier.
   3. All vibration isolators shall have either known undeflected heights or calibration markings so that, after adjustment, verified, thus determining that the load is within the proper range of the device and that the correct degree of vibration isolation is being provided according to the design.

4. All isolators shall operate in the linear portion of their load versus deflection curve. Load versus deflection curves shall be furnished by the manufacturer, and must be linear over a deflection range of not less than 50% above the design deflection.
5. The theoretical vertical natural frequency for each support point, based upon load per isolator and isolator stiffness, shall not differ from the design objectives for the equipment as a whole by more than ±10%.
6. All neoprene mountings shall have Shore hardness of 30 to 60 ±5, or as specified herein, after minimum aging of 20 days or corresponding over-aging.
7. Housed or caged spring isolators are not acceptable.
8. Where steel spring isolation systems are described in the specifications, the mounting assemblies shall utilize bare springs with the spring diameter not less than 80% of the loaded operating height of the spring. Each spring isolator shall be designed and installed so that the ends of the spring remain parallel during and after the spring installation. All isolators shall operate in the linear portion of their load versus deflection curve and have 50% excess capacity without becoming coil bound.
9. All mounting systems exposed to weather and other corrosive environments shall be protected with factory corrosion resistance. All metal parts of mountings (except springs and hardware) shall be hot dip galvanized. Springs shall be cadmium plated and neoprene coated. Nuts and bolts shall be cadmium plated.

B. ISOLATOR TYPE WP
1. Type WP (Waffle Pads) shall be 0.3 in. (8mm) thick neoprene pads ribbed or waffled on both sides. The pads shall be manufactured with bridge bearing quality neoprene, and selected for a maximum durometer of 40 and designed for 15% strain. Where required, steel load-spreading plates shall be incorporated between the equipment and the neoprene pad.
2. If the isolator is bolted to the structure, a neoprene vibration isolation washer and sleeve (Uniroyal Type 620/660 or as approved) shall be installed under the bolt head between the steel washer and the base plate.
3. Type WP: Mason Industries Type W, Super W, or as approved.

C. ISOLATOR TYPE DDNH
1. Type DDNH (Double Deflection Neoprene Hangers) shall consist of a molded neoprene isolating element in a steel hanger box. A neoprene sleeve shall be provided where the lower hanger rod passes through the steel hanger box, such that the hanger rod cannot contact the steel hanger. The diameter of the clear hole in the hanger box shall be at least 0.75 in. (19mm) larger than the diameter of the hanger rod and permit the hanger rod to swing through a 30° arc. When installed, the hanger box shall be allowed to rotate through a full 360° without encountering any obstructions.
2. The isolator shall be manufactured with bridge bearing quality neoprene, and selected for a maximum durometer of 40 and designed for 15% strain. Unless otherwise specified, the static deflection of DDNH hangers shall be 0.3 in. (8mm).
3. Type DDNH: Mason Industries Type HD or as approved.

D. ISOLATOR TYPE SPNM

1. Type SPNM (Spring and Neoprene Mounts) shall have a free-standing and laterally stable steel spring without any housing. Springs shall be designed so that the ratio of the horizontal to vertical spring constant is between one and two. The spring diameter shall be not less than 80% of the compressed height of the spring at rated load. Loaded springs shall have a minimum additional travel to solid equal to 50% of the specified static deflection.
2. Unless otherwise specified, the minimum static deflection of SPNM isolators under actual load conditions for equipment mounted on grade slabs shall be 1 in. (25mm), and the minimum static deflection under actual load conditions for equipment mounted above grade level shall be 2 in. (50mm).
3. Two Type WP isolation pads sandwiching a 16-gauge stainless or galvanized steel separator plate shall be bonded to the isolator baseplate.
4. Unless otherwise specified, isolators need not be bolted to the floor for indoor installations. If the base plates are bolted to the structure, a neoprene vibration isolation washer and sleeve (Uniroyal Type 620/660 or as approved) shall be installed under the bolt head between the steel washer and the base plate.
5. Type SPNM: Mason Industries Type SLFSW or as approved.

E. ISOLATOR TYPE SPNH
1. Type SPNH (Spring and Neoprene Hangers) shall consist of a steel spring in series with a neoprene isolating element. The spring shall have a minimum additional travel to solid equal to 50% of the specified deflection. The neoprene element shall have a static deflection of not less than 0.35 in. (9mm) with a strain not exceeding 15%.
2. Unless otherwise specified, the static deflection of SPNH hangers under actual load conditions shall be 2 in. (50mm).
3. Spring diameter and hanger box hole size shall be large enough to permit the hanger rod to swing through a 30° arc. A neoprene sleeve shall be provided where the lower hanger rod passes through the steel hanger box, such that the hanger rod cannot contact the steel hanger. The diameter of the clear hole in the hanger box shall be at least 0.75 in. (19mm) larger than the diameter of the hanger rod. When installed, the spring element shall not be cocked, and the hanger box shall be allowed to rotate through a full 360° arc without encountering any obstructions.
4. Type SPNH: Mason Industries Type 30N or as approved.

F. ISOLATOR TYPE CSNM
1. Type CSNM (Constrained Spring and Neoprene Mounts) shall be a spring and neoprene mount that incorporates a housing which incorporates unrestrained stable springs with built-in leveling device and resilient vertical limit stops to prevent spring elongation when partial load is removed and limits the movement of equipment when it is subjected to wind loading.
2. A minimum clearance of 1 in. (25mm) shall be maintained around restraining bolts and between the housing and the spring so as not to interfere with the spring operation. Limit stops shall provide minimum 0.25 in. (6mm) clearance under normal operation, and a neoprene washer shall be installed beneath the bolt head/ washer used to restrain the isolator.

3. In installations subject to wind load, provide tapped hole in top and bottom plates for bolting to equipment and the roof or supporting structure with a neoprene mounting sleeve.
4. Provide minimum 0.25 in. (6mm) thick neoprene acoustical base pad on underside of mount unless designated otherwise.
5. Mount shall be capable of supporting equipment at a fixed elevation during equipment erection. Installed and operating heights shall be identical.
6. Unless otherwise specified, the minimum static deflection for Type CSNM mounts under actual load conditions shall be 2 in. (50mm).
7. Type CSNM: Mason Industries Type SLR or as approved.

G. NEOPRENE MOUNTING SLEEVES
1. Neoprene mounting sleeves for hold-down applications of equipment with vibration isolators shall be Uniroyal Type 620/660 or as approved.

H. PIPE FLEXIBLE CONNECTORS
1. Flexible connectors for pipes shall be neoprene Mason Type MFNEC, MFTNC or as approved. Control cables (Mason Type ACC or equivalent) may be used to limit axial elongation, if necessary. Rigid control rods shall not be used for this purpose.

PART 3 - EXECUTION

3.1 GENERAL

A. All equipment, piping, etc. shall be mounted on or suspended from approved foundations and supports, all as specified herein, or as shown on the drawings.

B. All floor-mounted equipment shall be erected on 4 in. (100mm) thick concrete housekeeping pads over the complete floor area of the equipment, unless otherwise specified to the contrary herein. Wherever vibration eliminating devices and/or concrete inertia blocks are specified, these items shall, in all cases, be in turn mounted on concrete housekeeping pads unless otherwise specified to the contrary herein.

C. Furnish and install neoprene mounting sleeves for hold-down bolts to prevent any metal to metal contact.

D. All equipment shall be provided with lateral restraining isolators as required to limit horizontal motion to 0.25 in. (6mm) maximum, under all operating conditions. Lateral restraining isolators shall have the same static deflection as equipment being isolated.

E. Unless otherwise indicated, all equipment mounted on vibration isolators shall have a minimum operating clearance of 2 in. (50mm) between the bottom of the equipment or inertia base (and height-saving bracket) and the concrete housekeeping pad (or bolt heads) beneath the equipment. The clearance shall be checked by the Contractor to ensure that no material has been left to short- circuit the vibration isolators. There shall be a minimum 4 in. (100mm) clearance between isolated equipment and the walls, ceiling, floors, columns and any other equipment not installed on vibration isolators.

F. Piping, ductwork, conduit or mechanical equipment shall be supported from building structure, not hung from or supported on other equipment, pipes, or ductwork.

G. Equipment connected to water or other fluid piping shall be erected on isolators or isolated foundations at correct operating heights prior to connection of piping, and blocked-up with temporary shims to final operating height. When the system is assembled and fluid is added, the isolators shall be adjusted to allow removal of the shims.

H. All mechanical equipment not specifically identified in this specification that contains rotating or vibrating elements, and any associated electrical apparatus installed by this division that contains transformers or inductors shall be installed on Type DDNM or NIS neoprene isolators as appropriate.

I. All wiring connections to mechanical equipment on isolators shall be made with a minimum 36in. (900mm) long flexible conduit installed in a slack “U” shape.

J. Elastomeric isolators that will be exposed to temperatures below 0° C shall be fabricated from natural rubber instead of neoprene.

K. Springs shall be designed and installed so that ends of springs remain parallel and all springs are installed with adjustment bolts.

L. Springs shall be sized to be non-resonant with equipment forcing frequencies or support structure natural frequencies.

M. Refer to Vibration Isolation Schedule at the end of this Section.

3.2 MOUNTING OF FLOOR MOUNTED AIR HANDLING UNITS

A. Each floor-mounted fan or the fans in the packaged air handling unit shall be mounted on a Type SB base with Type SPNM isolators. The static deflection of the isolators shall be not less than 2 in. (50mm) under actual load conditions.

B. The structural steel supports beneath the spring isolators shall be equivalent to that under the perimeter of the air handling unit.

C. Drain pipe for air handling units shall be supported only from the isolated air handling unit frame. The condensate shall drip into a funnel that is supported from the floor or floor drain. A gap of at least 2 in. (50mm) shall be maintained between the end of the air handling unit drain pipe and funnel or floor drain. Hot and chilled water pipes shall be connected to the air handlers with flexible connectors.

3.3 PIPES CONNECTED TO EQUIPMENT ON SPRING ISOLATORS

A. All pipes connected to equipment installed on spring vibration isolators, except sprinkler piping, shall be suspended or supported by Type SPNM or Type SPNH isolators within mechanical equipment rooms. Provide vibration isolation anchors and guides as specified elsewhere in this specification.

B. The first isolator both upstream and downstream of equipment on springs shall have a static deflection equal to 1.5 times that of the equipment isolators, up to a maximum of 2 in. (50mm). The static deflection of the remaining pipe isolators shall be 1 in. (25mm).

3.4 PIPES CONNECTED TO EQUIPMENT ON NEOPRENE ISOLATORS

A. Piping that is connected only to machinery installed on neoprene isolators shall be either supported from the floor on Type DDNM mounts or suspended from the structure on Type DDNH hangers within the mechanical equipment rooms.

3.5 PIPES WITH MULTIPLE CONNECTIONS

A. Where a pipe run connects multiple items of equipment in the mechanical room the pipe isolators <u>for the entire</u> run shall be chosen to suit the connected equipment of greatest static deflection.

3.6 FLEXIBLE PIPING CONNECTORS

A. A. Flexible piping connectors shall be installed to connect piping diameter 2 in. (50mm) or greater to reciprocating or rotating equipment.

3.7 PIPING ISOLATION OUTSIDE MECHANICAL ROOMS

A. Except as noted elsewhere in this specification, outside the mechanical room all HVAC, compressed air, and domestic hot/cold water pipes with an inner diameter less than or equal to 2 in. (50mm) shall be isolated from the structure with sponge neoprene, felt or glass /mineral fiber sleeves between the pipe and pipe clamp or with Type WP pads between the clamp and the structure. When compressed, the sleeve shall be not less than 0.12 in. (3mm) in thickness.

B. All piping outside the mechanical room with inner diameter greater than 2 in. (50mm) shall be supported on Type SPNM isolators or suspended by Type SPNH isolators. Where piping is ganged on a trapeze the piping shall rest on the trapeze, which shall be isolated from the structure by the appropriate isolators. Neoprene pipe riser guides shall be used where lateral restraint is required.

3.8 PIPES CROSSING ACOUSTIC JOINTS

A. Any pipe crossing an acoustical joint shall have a twin-sphere neoprene flexible connector at the joint, with the exception of piping associated with fire protection, gas and compressed air, and shall be suspended by isolators as follows:
   1. Pipes with inner diameters less than 2 in. (50mm) shall be suspended by Type DDNH isolators for a minimum distance of 20 ft. (6 m) on each side of the joint.
   2. Pipes with an inner diameter of 2 in. (50mm) or greater shall be suspended on Type SPNH isolators for a minimum distance of 20 ft. (6 m) on the non-isolated structure and for the entire pipe length on the isolated structure.

3.9 PIPE RISERS

A. Where pipes rise in a vertical chase and are supported from a structure with type SPNH or DDNH isolators and require lateral bracing, neoprene riser guides shall be mounted around the pipe to limit lateral movement and to prevent direct contact with the supporting structure.

3.10 DUCT ISOLATION

A. All ducts shall be supported on either Type DDNM or Type DDNH isolators everywhere within mechanical equipment rooms.

B. Where a duct crosses an Acoustical Isolation Joint in the structure, the duct shall be supported by Type DDNM or DDNH isolators for a minimum of 5 times the outside duct height on each side of the joint. Otherwise, outside the mechanical room, no duct isolator supports are required unless shown in the mechanical drawings.

C. Ducts shall be connected to fans, fan casings and fan plenums by means of flexible connectors. Flexible connectors shall be installed to prevent metal-to-metal contact across flexible connection. Flexible duct connectors shall not be used outside the mechanical room unless expressly shown on the drawings.

3.11 DUCTWORK FABRICATION

A. Fabricate ductwork so as to be free from vibration, rattle or drumming under all operating conditions; provide all materials necessary for specified construction, whether or not they are specifically called for or detailed on the drawings.

3.12 BRACING OF DUCTWORK

A. Do not install tie rods within ducts serving noise critical spaces.

3.13 SHEET METAL AND PIPING PENETRATIONS OF SHAFTS, FLOOR SLAB AND/OR PARTITIONS

A. There shall be no direct contact of Sheet Metal or piping with shaft walls, floor slabs and/or partitions.

B. All openings around pipes and ducts in the structure surrounding the mechanical equipment and surrounding noise-critical spaces shall be packed for the full depth of the penetration and sealed with caulk, as described herein, and as shown on the drawings. This includes all slab penetrations and penetrations of noise critical walls.

3.14 DUCT PENETRATIONS

A. Where each duct passes through a wall, floor or ceiling, there shall be a clear annular space of 1 in. (25mm) between the duct and structure. After all of the ductwork is installed the Contractor shall check the clearance, pack the voids full depth with mineral fiber batt insulation and caulk both ends with a non-aging, non-hardening sealant backed by a polyethylene foam rod or permanently flexible firestop material. Where there is not sufficient access space to pack around all sides of a duct (for example, at the underside of a slab), place a short stub duct in the wall, pack and caulk around it and then attach the inlet and outlet ducts to each end.

3.15 PIPE PENETRATIONS

A. HVAC, Domestic Water, Sewer, Drain and Vent Piping
   1. Where a pipe passes through a wall, ceiling or floor slab, a steel sleeve shall be cast or grouted into the structure. The internal diameter of the sleeve shall be 2 in. (50mm) larger than the external diameter of the pipe passing through it. After all of the piping is installed in that area, the Contractor shall check the clearance and correct it, if necessary, to within 0.5 in. (13mm). Then the void shall be packed full depth with glass/mineral fiber and sealed at both ends, 1 in. (25mm) deep, with sealant backed by foam rod.

3.16 ACCESS PANELS

A. Access panels shall be installed only where shown on the drawings or approved by the acoustics consultant. All variations in access panel locations must be approved in writing by the acoustics consultant.

3.17 WIRING

A. All wiring connections to mechanical equipment on vibration isolators (either spring or neoprene type) shall be made with a minimum 36 in. (900mm) long flexible conduit in a slack U-shape. This Contractor shall coordinate wiring connections with the Electrical Contractor.

3.18 FIELD QUALITY

A. Contractor shall work in accord with best trade practices, shall fabricate and install all items in accordance with manufacturer's recommendations and Architect's directions, and shall consult with trades doing adjoining work in order to provide an installation of first class quality.

3.19 ADJUSTMENT AND TESTING

A. Site Access:
   1. During installation of equipment, Contractor shall arrange for access as necessary for inspection of isolation and noise control equipment by Architect and Acoustical Consultant.

B. Contractor's Report:
   1. The vibration isolation vendor shall inspect and approve the installation of the vibration isolators and shall submit a report to the Owner that verifies that all of the isolation equipment has been properly installed and that the installation is in full conformance with the specification. The report shall record the vibration isolator identification and model or type. For isolators containing steel springs the report shall also record the size and uncompressed height, design static deflection and measured static deflection of the isolators provided.

C. Consultant’s Inspection
   1. Upon completing installation and adjustment for suitable operation of all work specified under this section, the Contractor shall notify the Owner, Acoustics Consultant, and Architect in writing. The letter shall certify that all work specified under this section is complete, operational and adjusted in every respect, and that all work is ready for the completion checkout. The notification letter shall be accompanied by a copy of the air balancing report and the vibration isolation report.
   2. Upon notification of completion, Contractor will schedule an inspection the acoustics consultant, in the presence of Architect and Owner’s representative as appropriate, who will measure the background noise level with all Mechanical Systems running.
   3. For each inspection, Contractor shall perform such functions as are necessary for inspection of the equipment. Background noise level testing must be carried out during late-night hours when ambient noise from outside is at a minimum and the site is otherwise not occupied and no work is under way. Contractor shall turn on and off any and all mechanical equipment during such background noise level testing.

3.20 GUARANTEE

A. If, in the actual installation, any equipment fails to meet the noise or vibration control requirements specified herein, that equipment shall be corrected or replaced without claim for additional payment, inclusive of all labor and material costs. Such corrective measures shall be done within a time schedule specified by the Owner.

3.21 EXAMINATION

A. Section 01 30 00 - Administrative Requirements: Coordination and project conditions.

B. Verify equipment, ductwork and piping is installed before work in this section is started.

3.22 EXISTING WORK

A. Provide access to existing piping and ductwork and other installations remaining active and requiring access.

B. Extend existing piping and ductwork installations using materials and methods compatible with existing installations.

3.23 INSTALLATION

A. Support duct silencers independent of ductwork: Refer to Section 23 33 00.

B. Install cross-talk silencers in wall. Caulk wall penetrations; refer to Section 07 90 00.

C. Lag ductwork, where indicated by wrapping with insulation and covering. Apply covering to be airtight. Do not attach covering rigidly to ductwork.

D. Attach ductwork to acoustic louvers with flexible duct connections. Refer to Section 23 33 00.

E. Install isolation for motor driven equipment.

F. Bases:
   1. Set steel bases for 1 inch (25 mm) clearance between housekeeping pad and base.
   2. Set concrete inertia bases for 2 inch (50 mm) clearance between housekeeping pad and base.

G. Adjust equipment level.

H. Install spring hangers without binding.

I. Prior to making piping connections to equipment with operating weights substantially different from installed weights, block up equipment with temporary shims to final height. When full load is applied, adjust isolators to load to allow shim removal.

J. Provide pairs of thrust restraint horizontal limit springs on fans based on static pressure as scheduled.

K. Provide resiliently mounted equipment, piping, and ductwork with snubbers. Provide each inertia base with minimum of four snubbers located close to isolators. Snub equipment designated for post disaster use to 0.05 inch (1.5 mm) maximum clearance. Provide other snubbers with clearance between 0.15 inch (4 mm) and 0.25 inch (7 mm).

L. Support piping connections to isolated equipment resiliently for distance scheduled in Part 3.33.
   1. Select three hangers closest to vibration source for minimum 1.0 inch (25 mm) static deflection or static deflection of isolated equipment, whichever is larger. Select remaining isolators for minimum 1.0 inch (25 mm) static deflection or 1.2 times the static deflection of isolated equipment, whichever is larger.

M. Provide bracing per latest applicable building codes for all piping systems suspended more than 12 inches from the structural support system above.

3.24 FIELD QUALITY CONTROL

A. Section 01 XX XX - Quality Requirements and 01 XX XX - Execution and Closeout Requirements: Field inspecting, testing, adjusting, and balancing.

B. Inspect isolated equipment after installation and submit report. Include static deflections.

C. Use meters meeting requirements of ANSI S1.4.

D. Present vibration measurement data in comparison with the limitations of ASHRAE 2003 Applications table 41 on page 47.40 for allowable RMS velocity.

E. Present sound data as compared to performance criteria.

3.25 SCHEDULES

A. See vibration isolation requirements in this section for specific isolation for various Division 23 equipment.

B. Pipe Isolation Schedule:

PIPE SIZE IN INCHES	ISOLATED DISTANCE FROM EQUIPMENT IN DIAMETERS
1	120 diameters
2	90 diameters

C. Vibration Isolation Schedule for Mechanical Equipment

EQUIPMENT	BASE TYPE	ISOLATOR TYPE	STATIC DEFLECTION
Precision Cooling Units		Neoprene Pad	¼ in

Dry Coolers		CSNM	2 in
Inline Pumps		SPNH	¾ in
Expansion Tanks		Neoprene Pad	¼ in
Piping & Ductwork		Isolation as per requirements herein	

END OF SECTION

SECTION 230553 - IDENTIFICATION FOR MECHANICAL

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 mechanical identification materials and their installation:
   1. Equipment nameplates.
   2. Equipment markers.
   3. Access panel and door markers.
   4. Pipe markers.
   5. Duct markers.
   6. Stencils.
   7. Valve tags.
   8. Valve schedules.
   9. Warning tags.

1.3 SUBMITTALS

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

B. Valve numbering scheme.

C. Valve Schedules: For each piping system. Furnish extra copies (in addition to mounted copies) to include in maintenance manuals.

1.4 QUALITY ASSURANCE

A. ASME Compliance: Comply with ASME A13.1, "Scheme for the Identification of Piping Systems," for letter size, length of color field, colors, and viewing angles of identification devices for piping.

1.5 COORDINATION

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 location of access panels and doors.

C. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Brady Corporation.
   2. Marking Services, Inc.
   3. Seton Identification Products.

2.2 EQUIPMENT IDENTIFICATION DEVICES

A. Equipment Nameplates: Metal, with data engraved or stamped, factory installed on equipment.
   1. Data:
      a. Manufacturer, product name, model number, and serial number.
      b. Capacity, operating and power characteristics, and essential data.
      c. Labels of tested compliances.
   2. Location: Accessible and visible.
   3. Fasteners: As required to mount on equipment.

B. Equipment Markers: Engraved, color-coded laminated plastic. Include contact-type, permanent adhesive, or self-tapping stainless steel screws.
   1. Terminology: Match schedules as closely as possible.
   2. Data:
      a. Name and plan number.
      b. Equipment service.
   3. Size: 2-1/2 by 4 inches for control devices, dampers, and valves; 4-1/2 by 6 inches for equipment.

C. Access Panel and Door Markers: 1/16-inch- thick, engraved laminated plastic, with abbreviated terms and numbers corresponding to identification. Provide 1/8-inch center hole for attachment.
   1. Fasteners: Self-tapping, stainless-steel screws or contact-type, permanent adhesive.

2.3 PIPING IDENTIFICATION DEVICES

A. Manufactured Pipe Markers, General: Preprinted, color-coded, with lettering indicating service, and showing direction of flow.
   1. Colors: Comply with ASME A13.1, unless otherwise indicated.
      a. Rainwater harvesting systems shall be purple in color.
   2. Lettering: Use piping system terms indicated and abbreviate only as necessary for each application length.
   3. Length of Marker and Letter Sizes: Comply with applicable Plumbing & Fuel Gas Code.
   4. Pipes with OD, Including Insulation, Less Than 6 Inches: Full-band pipe markers extending 360 degrees around pipe at each location.
   5. Pipes with OD, Including Insulation, 6 Inches and Larger: Either full-band or strip-type pipe markers at least three times letter height and of length required for label.
   6. Arrows: Integral with piping system service lettering to accommodate both directions; or as separate unit on each pipe marker to indicate direction of flow.
   7. Exterior Applications: UV rated and rated for exterior use, including ambient conditions from 0°F to 100°F.

B. Pretensioned Pipe Markers: Precoiled semirigid plastic formed to cover full circumference of pipe and to attach to pipe without adhesive.

C. Shaped Pipe Markers: Preformed semirigid plastic formed to partially cover circumference of pipe and to attach to pipe with mechanical fasteners that do not penetrate insulation vapor barrier.

D. Self-Adhesive Pipe Markers: Plastic with pressure-sensitive, permanent-type, self-adhesive back.

E. Plastic Tape: Continuously printed, vinyl tape at least 3 mils thick with pressure-sensitive, permanent-type, self-adhesive back.
   1. Width for Markers on Pipes with OD, Including Insulation, 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.

2.4 STENCILS

A. Stencils: Prepared with minimum letter height of 1-1/4 inches for ducts; and minimum letter height of 3/4 inch for access panel and door markers, and similar operational instructions.
   1. Stencil Material: Metal or fiberboard.
   2. Stencil Paint: Exterior, gloss, acrylic enamel black, unless otherwise indicated. Paint may be in pressurized spray-can form.
   3. Identification Paint: Exterior, acrylic enamel in colors according to ASME A13.1, unless otherwise indicated.

2.5 VALVE TAGS

A. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers, with numbering scheme approved by Architect. Provide 5/32-inch hole for fastener.
   1. Material: 0.032-inch- thick brass.
   2. Valve-Tag Fasteners: Brass wire-link chain.

2.6 VALVE SCHEDULES

A. Valve Schedules: For each piping system, on standard-size 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-Schedule Frames: Glazed display frame for removable mounting on masonry walls for each page of valve schedule. Include mounting screws.
   2. Frame: Extruded aluminum.
   3. Glazing: ASTM C 1036, Type I, Class 1, Glazing Quality B, 2.5-mm, single-thickness glass.

2.7 WARNING TAGS

A. Warning Tags: Preprinted or partially preprinted, accident-prevention tags; of plasticized card stock with matte finish suitable for writing.
   1. Size: 3 by 5-1/4 inches minimum.
   2. Fasteners: Brass grommet and wire.
   3. Nomenclature: Large-size primary caption such as DANGER, CAUTION, or DO NOT OPERATE.
   4. Color: Yellow background with black lettering.

2.8 PLUMBING FIXTURE AND ROOM SIGNAGE

A. General: In accordance with Section 10 14 23 “Panel Signage”

PART 3 - EXECUTION

3.1 APPLICATIONS, GENERAL

A. Products specified are for applications referenced in other Division 23 Sections. If more than single-type material, device, or label is specified for listed applications, selection is Installer's option.

3.2 EQUIPMENT IDENTIFICATION

A. Install and permanently fasten equipment nameplates on each major item of mechanical equipment that does not have nameplate or has nameplate that is damaged or located where not easily visible. Locate nameplates where accessible and visible. Include nameplates for the following general categories of equipment:
   1. Pumps, compressors, chillers, condensers, and similar motor-driven units.
   2. Heat exchangers, coils, evaporators, cooling towers, and similar equipment.
   3. Fans, blowers, and primary balancing dampers.
   4. Packaged and Custom HVAC central-station and zone-type units.
   5. Domestic water heaters, expansion/compression tanks.

B. Install equipment markers with permanent adhesive on or near each major item of mechanical equipment.
   1. Letter Size: Minimum 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-fourths the size of principal lettering.
   2. Data: Distinguish among multiple units, indicate operational requirements, indicate safety and emergency precautions, warn of hazards and improper operations, and identify units.
   3. Locate markers where accessible and visible. Include markers for the following general categories of equipment:
      a. Main control and operating valves, including safety devices and hazardous units such as gas outlets.
      b. Meters, gages, thermometers, and similar units.
      c. Pumps, compressors, chillers, condensers, and similar motor-driven units.
      d. Heat exchangers, coils, evaporators, dry coolers, heat recovery units, and similar equipment.

e. Fans, blowers, and primary balancing dampers.
f. Packaged and Custom HVAC central-station and zone-type units.
g. Tanks and pressure vessels.
h. Strainers, filters, humidifiers, water-treatment systems, and similar equipment.
i. ATC panels, controllers, valves, dampers, sensors, etc.
j. Air handling units to identify associated exhaust fan systems, if applicable.

C. Install access panel markers with screws on equipment access panels.

3.3 PIPING IDENTIFICATION

A. Install manufactured pipe markers indicating service on each piping system. Install with flow indication arrows showing direction of flow.
1. Exterior Pipes with OD, Including Insulation, Less Than 6 Inches: Pretensioned pipe markers. Use size to ensure a tight fit.
2. Interior Pipes with OD, Including Insulation, Less Than 6 Inches : Self-adhesive pipe markers. Use color-coded, self-adhesive plastic tape, at least 3/4 inch wide, lapped at least 1-1/2 inches at both ends of pipe marker, and covering full circumference of pipe.
3. Exterior Pipes with OD, Including Insulation, 6 Inches and Larger: Shaped pipe markers. Use size to match pipe and secure with fasteners.
4. Interior Pipes with OD, Including Insulation, 6 Inches and Larger: Self-adhesive pipe markers. Use color-coded, self-adhesive plastic tape, at least 1-1/2 inches wide, lapped at least 3 inches at both ends of pipe marker, and covering full circumference of pipe.

B. Locate pipe markers and color bands where piping is exposed in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior nonconcealed 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 through walls, floors, ceilings, and nonaccessible 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 markers.

3.4 DUCT IDENTIFICATION

A. Install stenciled markers on ductwork:
1. Stenciled Duct Marker: Stenciled markers, showing designation of equipment serving ducts (AHU-1, etc.), service (supply-air, etc.) and direction of flow. Note associated air handling units or exhaust fans on systems that tie together for heat recovery.

B. Locate markers near points where ducts enter into concealed spaces and at maximum intervals of 50 feet in each space where ducts are exposed or concealed by removable ceiling system.

3.5 VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in piping systems, except check valves; valves immediately adjacent to factory-fabricated equipment units; 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:
1. Valve-Tag Size and Shape:
   a. Cold Water (HVAC and Plumbing): 1-1/2 inches, round.
   b. Hot Water (HVAC and Plumbing): 1-1/2 inches, round.
2. Valve-Tag Color:
   a. Cold Water (HVAC and Plumbing): Green.
   b. Hot Water (HVAC and Plumbing): Yellow.
3. Letter Color:
   a. Cold Water: White.
   b. Hot Water: Black.

3.6 VALVE-SCHEDULE INSTALLATION

A. Mount valve schedule on wall in accessible location in each major equipment room.

3.7 WARNING-TAG INSTALLATION

A. Write required message on, and attach warning tags to, equipment and other items where required.

3.8 PLUMBING FIXTURE AND ROOM SIGNAGE

A. General: At Each Non-Potable Outlets, including Hose Connections, and Other Outlet Connection, sign to read “Non-Potable – Not Safe For Drinking” or other approved wording.

3.9 ADJUSTING

A. Relocate mechanical identification materials and devices that have become visually blocked by other work.

3.10 CLEANING

A. Clean faces of mechanical identification devices and glass frames of valve schedules.

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. This Section includes Testing, Adjusting, and Balancing (TAB) to produce design objectives for the following:
   1. Air Systems:
      a. Constant-volume air systems.
      b. Variable-air-volume systems.
   2. Hydronic Piping Systems:
      a. Constant-flow systems.
   3. HVAC equipment quantitative-performance settings.
   4. Sound level measuring.
   5. Verifying that automatic control devices are functioning properly.
   6. Witnessing duct leakage testing.
   7. Reporting results of activities and procedures specified in this Section.

B. Related Sections include the following:
   1. Most of the mechanical systems are included in the Commissioning Program. Refer to the following specification sections for requirements associated with Commissioning:
      a. Section 019113 “General Commissioning Requirements.”
      b. Section 230800 “Commissioning of Mechanical Systems”.
   2. Section 230548 “Mechanical Vibration Control” for vibration measuring.

1.3 DEFINITIONS

A. Adjust: To regulate fluid flow rate and air patterns at the terminal equipment, such as to reduce fan speed or adjust a damper.

B. Balance: To proportion flows within the distribution system, including submains, branches, and terminals, according to indicated quantities.

C. Barrier or Boundary: Construction, either vertical or horizontal, such as walls, floors, and ceilings that are designed and constructed to restrict the movement of airflow, smoke, odors, and other pollutants.

D. Draft: A current of air, when referring to localized effect caused by one or more factors of high air velocity, low ambient temperature, or direction of airflow, whereby more heat is withdrawn from a person's skin than is normally dissipated.

E. NC: Noise criteria.

F. Procedure: An approach to and execution of a sequence of work operations to yield repeatable results.

G. RC: Room criteria.

H. Report Forms: Test data sheets for recording test data in logical order.

I. Static Head: The pressure due to the weight of the fluid above the point of measurement. In a closed system, static head is equal on both sides of the pump.

J. Suction Head: The height of fluid surface above the centerline of the pump on the suction side.

K. System Effect: A phenomenon that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.

L. System Effect Factors: Allowances used to calculate a reduction of the performance ratings of a fan when installed under conditions different from those presented when the fan was performance tested.

M. TAB: Testing, adjusting, and balancing.

N. Terminal: A point where the controlled medium, such as fluid or energy, enters or leaves the distribution system.

O. Test: A procedure to determine quantitative performance of systems or equipment.

P. Testing, Adjusting, and Balancing (TAB) Firm: The entity responsible for performing and reporting TAB procedures.

1.4 SUBMITTALS

A. Qualification Data: Within 45 days from Contractor's Notice to Proceed, submit evidence that TAB firm and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.

B. Contract Documents Examination Report: Within 45 days from Contractor's Notice to Proceed, submit the Contract Documents review report as specified in Part 3.

C. Strategies and Procedures Plan: Within 90 days from Contractor's Notice to Proceed, submit TAB strategies and step-by-step procedures as specified in Part 3 "Preparation" Article. Include a complete set of report forms intended for use on this Project, certification of instrument calibration, and instrument serial numbers.

D. Certified TAB Reports: Submit two copies of reports prepared, as specified in this Section, on approved forms certified by TAB firm.

E. Ceiling Coordination Shop Drawings:
1. Access doors will not be provided for supply and return air devices in gypsum board or plaster ceilings.
2. Submit to the Construction Manager, ceiling coordination drawings for areas with hard gypsum board or plaster ceilings. Drawings shall indicate both minimum and maximum

allowable areas of ceilings to be installed prior to testing and balancing of supply and return air devices and associated volume dampers. Minimum area shall be enough ceiling to allow testing and balancing to occur and assure the same air device performance once the ceilings are complete. Maximum area shall leave enough openings in the ceiling to access volume dampers and other components necessary to test and balance.

3. Utilize sheet metal installation drawings as base plans for ceiling coordination drawings. Sheetmetal installation drawings are specified in Section 233113 “Metal Ducts.”

F. Certified duct pressure test reports.

G. Warranties specified in this Section.

1.5 QUALITY ASSURANCE

A. TAB Firm Qualifications: Engage a TAB firm certified by either AABC or NEBB.

B. TAB Conference: Meet with Owner's and Architect's representatives on approval of TAB strategies and procedures plan to develop a mutual understanding of the details. Ensure the participation of TAB team members, equipment manufacturers' authorized service representatives, HVAC controls installers, and other support personnel. Provide seven days' advance notice of scheduled meeting time and location.

1. Agenda Items: Include at least the following:
    a. Submittal distribution requirements.
    b. The Contract Documents examination report.
    c. TAB plan.
    d. Work schedule and Project-site access requirements.
    e. Coordination and cooperation of trades and subcontractors.
    f. Coordination of documentation and communication flow.

C. Certification of TAB Reports: Certify TAB field data reports. This certification includes the following:

1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.
2. Certify that TAB team complied with approved TAB plan and the procedures specified and referenced in this Specification.

D. TAB Report Forms: Use standard forms from AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems", NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems", or SMACNA's "HVAC Systems - Testing, Adjusting, and Balancing."

E. Instrumentation Type, Quantity, and Accuracy: As described in AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems," Section II, "Required Instrumentation for NEBB Certification."

F. Instrumentation Calibration: Calibrate instruments at least every six months or more frequently if required by instrument manufacturer.

1. Keep an updated record of instrument calibration that indicates date of calibration and the name of party performing instrument calibration.

1.6 COORDINATION

A. Coordinate the efforts of factory-authorized service representatives for systems and equipment, HVAC controls installers, and other mechanics to operate HVAC systems and equipment to support and assist TAB activities.

B. Notice: Provide seven days' advance notice for each test. Include scheduled test dates and times.

C. Perform TAB after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.

D. Coordinate partial installation of gypsum wall board and plaster ceilings to permit balancing of supply and exhaust air devices without use of access doors.

1.7 WARRANTY

A. Provide one of the following:
   1. National Project Performance Guarantee: Provide a guarantee on AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems" forms stating that AABC will assist in completing requirements of the Contract Documents if TAB firm fails to comply with the Contract Documents. Guarantee includes the following provisions:
      a. The certified TAB firm has tested and balanced systems according to the Contract Documents.
      b. Systems are balanced to optimum performance capabilities within design and installation limits.
   2. Special Guarantee: Provide a guarantee on NEBB forms stating that NEBB will assist in completing requirements of the Contract Documents if TAB firm fails to comply with the Contract Documents. Guarantee shall include the following provisions:
      a. The certified TAB firm has tested and balanced systems according to the Contract Documents.
      b. Systems are balanced to optimum performance capabilities within design and installation limits.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 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.
   1. Contract Documents are defined in the General and Supplementary Conditions of Contract.
   2. Verify that balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are required by the Contract Documents. Verify that quantities and locations of these balancing devices are accessible and appropriate for effective balancing and for efficient system and equipment operation.

B. Examine approved submittal data of HVAC systems and equipment.

C. Examine Project Record Documents described in Section 017200 "Project Record Documents."

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 equipment performance data including fan and pump curves. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system. Calculate system effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from those presented when the equipment was performance tested at the factory. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," Sections 7 through 10; or in SMACNA's "HVAC Systems--Duct Design," Sections 5 and 6. Compare this data with the design data and installed conditions.

F. Examine system and equipment installations to verify that they are complete and that testing, cleaning, adjusting, and commissioning specified in individual Sections have been performed.

G. Examine system and equipment test reports.

H. Examine HVAC system and equipment installations to verify that indicated balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are properly installed, and that their locations are accessible and appropriate for effective balancing and for efficient system and equipment operation.

I. Examine systems for functional deficiencies that cannot be corrected by adjusting and balancing.

J. Examine HVAC equipment to ensure that clean filters have been installed, bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.

K. Examine terminal units, such as variable-air-volume boxes, to verify that they are accessible and their controls are connected and functioning.

L. Examine strainers for clean screens and proper perforations.

M. Examine three-way valves for proper installation for their intended function of diverting or mixing fluid flows.

N. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

O. Examine system pumps to ensure absence of entrained air in the suction piping.

P. Examine equipment for installation and for properly operating safety interlocks and controls.

Q. Examine automatic temperature control system components to verify the following:
   1. Dampers, valves, and other controlled devices are operated by the intended controller.

2. Dampers and valves are in the position indicated by the controller.
3. Integrity of valves and dampers for free and full operation and for tightness of fully closed and fully open positions. This includes dampers in mixing boxes and variable-air-volume terminals.
4. Automatic modulating and shutoff valves, including two-way valves and three-way mixing and diverting valves, are properly connected.
5. Thermostats and humidistats are located to avoid adverse effects of sunlight, drafts, and cold walls.
6. Sensors are located to sense only the intended conditions.
7. Sequence of operation for control modes is according to the Contract Documents.
8. Controller set points are set at indicated values.
9. Interlocked systems are operating.
10. Changeover from heating to cooling mode occurs according to indicated values.

R. 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.

3.2 PREPARATION

A. Prepare a TAB plan that includes strategies and step-by-step procedures.

B. Complete system readiness checks and prepare system readiness reports. Verify the following:
1. Permanent electrical power wiring is complete.
2. Hydronic systems are filled, clean, and free of air.
3. Automatic temperature-control systems are operational.
4. Equipment and duct access doors are securely closed.
5. Balance, smoke, and fire dampers are open.
6. Isolating and balancing valves are open and control valves are operational.
7. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.
8. Windows and doors can be closed so indicated conditions for system operations can be met.

3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems", NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems", or SMACNA's "HVAC Systems - Testing, Adjusting, and Balancing"; and this Section.

B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary to allow adequate performance of procedures. After testing and balancing, close probe holes and patch insulation with new materials identical to those removed. Restore vapor barrier and finish according to insulation Specifications for this Project.

C. Mark equipment and balancing device settings with paint or other suitable, permanent identification material, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, to show final settings.

D. Take and report testing and balancing measurements in inch-pound (IP) units.

3.4 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.

B. Prepare schematic diagrams of systems' "as-built" duct layouts where different from layouts on construction drawings.

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 outside-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. Check for proper sealing of air duct system.

3.5 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 fan static pressures to determine actual static pressure as follows:
      a. Measure outlet static pressure as far downstream from the fan as practicable and upstream from restrictions in ducts such as elbows and transitions.
      b. Measure static pressure directly at the fan outlet or through the flexible connection.
      c. Measure inlet static pressure of single-inlet fans in the inlet duct as near the fan as possible, upstream from flexible connection and downstream from duct restrictions.
      d. Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan.
   2. Measure static pressure across each component that makes up an air-handling unit and other air-handling and -treating equipment.
      a. Simulate dirty filter operation and record the point at which maintenance personnel must change filters.
   3. Measure static pressures entering and leaving other devices such as sound traps, heat recovery equipment, and air washers, under final balanced conditions.

4. Compare design data with installed conditions to determine variations in design static pressures versus actual static pressures. Compare actual system effect factors with calculated system effect factors to identify where variations occur. Recommend corrective action to align design and actual conditions.
5. Obtain approval from Architect for adjustment of fan speed higher or lower than indicated speed. Make required adjustments to pulley sizes, motor sizes, and electrical connections to accommodate fan-speed changes.
6. 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 will occur. Measure amperage in full cooling, full heating, economizer, and any other operating modes to determine the maximum required brake horsepower.

B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows within specified tolerances.
   1. Measure static pressure at a point downstream from the balancing damper and adjust volume dampers until the proper static pressure is achieved.
      a. Where sufficient space in submain and branch ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow for that zone.
   2. Remeasure each submain and branch duct after all have been adjusted. Continue to adjust submain and branch ducts to indicated airflows within specified tolerances.

C. Measure terminal outlets and inlets without making adjustments.
   1. Measure terminal outlets using a direct-reading hood or outlet manufacturer's written instructions and calculating factors.

D. Adjust terminal outlets and inlets for each space to indicated airflows within specified tolerances of indicated values. Make adjustments using volume dampers rather than extractors and the dampers at air terminals.
   1. Adjust each outlet in same room or space to within specified tolerances of indicated quantities without generating noise levels above the limitations prescribed by the Contract Documents.
   2. Adjust patterns of adjustable outlets for proper distribution without drafts.

3.6 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

A. Compensating for Diversity: When the total airflow of all terminal units is more than the indicated airflow of the fan, place a selected number of terminal units at a maximum set-point airflow condition until the total airflow of the terminal units equals the indicated airflow of the fan. Select the reduced airflow terminal units so they are distributed evenly among the branch ducts.

B. Pressure-Independent, Variable-Air-Volume Systems: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:
   1. Set outside-air dampers at minimum, and return- and exhaust-air dampers at a position that simulates full-cooling load.
   2. Select the terminal unit that is most critical to the supply-fan airflow and static pressure. Measure static pressure. Adjust system static pressure so the entering static pressure for the critical terminal unit is not less than the sum of terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.

3. Measure total system airflow. Adjust to within indicated airflow.
4. Set terminal units at maximum airflow and adjust controller or regulator to deliver the designed maximum airflow. Use terminal-unit manufacturer's written instructions to make this adjustment. When total airflow is correct, balance the air outlets downstream from terminal units as described for constant-volume air systems.
5. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow as described for constant-volume air systems.
   a. If air outlets are out of balance at minimum airflow, report the condition but leave outlets balanced for maximum airflow.
6. Remeasure the return airflow to the fan while operating at maximum return airflow and minimum outside airflow. Adjust the fan and balance the return-air ducts and inlets as described for constant-volume air systems.
7. Measure static pressure at the most critical terminal unit and adjust the static-pressure controller at each supply-air sensing station to ensure that adequate static pressure is maintained at the most critical unit. Coordinate setpoint with BAS Contractor.
8. Record the final fan performance data.

3.7 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

A. Prepare test reports with pertinent design data and number in sequence starting at pump to end of system. Check the sum of branch-circuit flows against approved pump flow rate. Correct variations that exceed plus or minus 5 percent.

B. Prepare schematic diagrams of systems' "as-built" piping layouts where different from layouts on construction drawings.

C. For variable-flow systems, develop a plan to simulate diversity.

D. Prepare hydronic systems for testing and balancing according to the following, in addition to the general preparation procedures specified above:
   1. Open all manual valves for maximum flow.
   2. Check expansion tank liquid level.
   3. Check makeup-water-station pressure gage for adequate pressure for highest vent.
   4. Check flow-control valves for specified sequence of operation and set at indicated flow.
   5. Set differential-pressure control valves at the specified differential pressure. Do not set at fully closed position when pump is positive-displacement type unless several terminal valves are kept open.
   6. Set system controls so automatic valves are wide open to heat exchangers.
   7. Check pump-motor load. If motor is overloaded, throttle main flow-balancing device so motor nameplate rating is not exceeded.
   8. Check air vents for a forceful liquid flow exiting from vents when manually operated.

3.8 PROCEDURES FOR HYDRONIC SYSTEMS

A. Measure water flow at pumps. Use the following procedures, except for positive-displacement pumps:
   1. Verify impeller size by operating the pump with the discharge valve closed. Read pressure differential across the pump. Convert pressure to head and correct for differences in gage heights. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.

2. Check system resistance. With all valves open, read pressure differential across the pump and mark pump manufacturer's head-capacity curve. Adjust pump discharge valve until indicated water flow is achieved.
3. Verify pump-motor brake horsepower. Calculate the intended brake horsepower for the system based on pump manufacturer's performance data. Compare calculated brake horsepower with nameplate data on the pump motor. Report conditions where actual amperage exceeds motor nameplate amperage.
4. Report flow rates that are not within plus or minus 5 percent of design.

B. Set calibrated balancing valves, if installed, at calculated presettings.

C. Measure flow at all stations and adjust, where necessary, to obtain first balance.
   1. System components that have Cv rating or an accurately cataloged flow-pressure-drop relationship may be used as a flow-indicating device.

D. Measure flow at main balancing station and set main balancing device to achieve flow that is 5 percent greater than indicated flow.

E. Adjust balancing stations to within specified tolerances of indicated flow rate as follows:
   1. Determine the balancing station with the highest percentage over indicated flow.
   2. Adjust each station in turn, beginning with the station with the highest percentage over indicated flow and proceeding to the station with the lowest percentage over indicated flow.
   3. Record settings and mark balancing devices.

F. Measure pump flow rate and make final measurements of pump amperage, voltage, rpm, pump heads, and systems' pressures and temperatures including outdoor-air temperature.

G. Measure the differential-pressure control valve settings at the conclusion of balancing.

3.9 PROCEDURES FOR MOTORS

A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:
   1. Manufacturer, model, and serial numbers.
   2. Motor horsepower rating.
   3. Motor rpm.
   4. Efficiency rating.
   5. Nameplate and measured voltage, each phase.
   6. Nameplate and measured amperage, each phase.
   7. Starter thermal-protection-element rating.

B. Motors Driven by Variable-Frequency Controllers: Test for proper operation at speeds varying from minimum to maximum. Test the manual bypass for the controllerif provided) to prove proper operation. Record observations, including controller manufacturer, model and serial numbers, and nameplate data.

3.10 PROCEDURES FOR HEAT-TRANSFER COILS

A. Water Coils: Measure the following data for each coil:
   1. Entering- and leaving-water temperature.
   2. Water flow rate.

3. Water pressure drop.
4. Dry-bulb temperature of entering and leaving air.
5. Wet-bulb temperature of entering and leaving air for cooling coils.
6. Airflow.
7. Air pressure drop.

B. Refrigerant Coils: Measure the following data for each coil:
1. Dry-bulb temperature of entering and leaving air.
2. Wet-bulb temperature of entering and leaving air.
3. Airflow.
4. Air pressure drop.
5. Refrigerant suction pressure and temperature.

3.11 PROCEDURES FOR TEMPERATURE MEASUREMENTS

A. During TAB, report the need for adjustment in temperature regulation within the automatic temperature-control system.

B. Measure indoor wet- and dry-bulb temperatures every other hour for a period of two successive eight-hour days, in five separately controlled zones (or as many zones exist if less than five) of each of the following space types to prove correctness of final temperature settings. Measure when the building or zone is occupied.
1. Theater – main level.
2. Theater – balcony level.
3. Black Box.
4. Lobby/Foyer.
5. Balcony Gallery.
6. Classroom.
7. Dressing Room.
8. Office.

C. Measure outside-air, wet- and dry-bulb temperatures.

D. Coordinate temperature measurements with instruments and sensors calibration specified in Section 230900 “Instrumentation and Control for HVAC.”

3.12 PROCEDURES FOR SOUND-LEVEL MEASUREMENTS

A. Perform sound-pressure-level measurements with an octave-band analyzer complying with ANSI S1.4 for Type 1 sound-level meters and ANSI S1.11 for octave-band filters. Comply with requirements in ANSI S1.13, unless otherwise indicated.

B. Calibrate sound meters before each day of testing. Use a calibrator provided with the sound meter complying with ANSI S1.40.

C. Use a microphone that is suitable for the type of sound levels measured. For areas where air velocities exceed 100 fpm, use a windscreen on the microphone.

D. Perform sound-level testing after air and water balancing and equipment testing are complete.

E. Close windows and doors to the space.

F. Perform measurements when the space is not occupied and when the occupant noise level from other spaces in the building and outside are at a minimum.

G. Clear the space of temporary sound sources so unrelated disturbances will not be measured. Position testing personnel during measurements to achieve a direct line-of-sight between the sound source and the sound-level meter.

H. Take sound measurements at a height approximately 48 inches above the floor and at least 36 inches from a wall, column, and other large surface capable of altering the measurements.

I. Take sound measurements in dBA and in each of the 8 unweighted octave bands in the frequency range of 63 to 8000 Hz.

J. Take sound measurements with the HVAC systems off to establish the background sound levels and take sound measurements with the HVAC systems operating.
   1. Calculate the difference between measurements. Apply a correction factor depending on the difference and adjust measurements.

3.13 DUCT LEAKAGE TESTING

A. Witness leakage tests of ductwork. Duct leakage tests are specified in Section 233113 “Metal Ducts.”

3.14 TOLERANCES

A. Set HVAC system airflow and water flow rates within the following tolerances:
   1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus 5 to plus 10 percent.
   2. Air Outlets and Inlets: 0 to minus 10 percent.
   3. Cooling-Water Flow Rate: 0 to minus 5 percent.

3.15 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: As Work progresses, prepare reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

3.16 FINAL REPORT

A. General: Typewritten, or computer printout in letter-quality font, on standard bond paper, in three-ring binder, tabulated and divided into sections by tested and balanced systems.

B. Include a certification sheet in front of binder signed and sealed by the certified testing and balancing engineer.

1. Include a list of instruments used for procedures, along with proof of calibration.

C. 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, but do not include Shop Drawings and Product Data.

D. General Report Data: In addition to form titles and entries, include the following data in the final report, as applicable:
   1. Title page.
   2. Name and address of TAB firm.
   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 firm 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, type size, and fittings.
   14. Notes to explain why certain final data in the body of reports varies from indicated values.
   15. Test conditions for fans and pump performance forms including the following:
       a. Settings for outside-, return-, and exhaust-air dampers.
       b. Conditions of filters.
       c. Cooling coil, wet- and dry-bulb conditions.
       d. Face and bypass damper settings at coils.
       e. Fan drive settings including settings and percentage of maximum pitch diameter.
       f. Variable frequency controller settings for variable-air-volume systems.
       g. Settings for supply-air, static-pressure controller.
       h. Other system operating conditions that affect performance.

E. 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 outside, supply, return, and exhaust airflows.
   2. Water 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.

F. Air-Handling Unit Test Reports: For air-handling units with coils, include the following:

1. Unit Data: Include the following:
    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. Sheave dimensions, center-to-center, and amount of adjustments in inches.
    j. Number of belts, make, and size.
    k. Number of filters, type, and size.
2. Motor Data:
    a. 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. Sheave dimensions, center-to-center, 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 wg.
    g. Cooling coil static-pressure differential in inches wg.
    h. Heating coil static-pressure differential in inches wg.
    i. Humidifier dispersion manifold static-pressure differential in inches wg.
    j. Outside airflow in cfm.
    k. Return airflow in cfm.
    l. Outside-air damper position.
    m. Return-air damper position.

G. 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. Outside-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 suction pressure in psig.
m. Refrigerant suction temperature in deg F.

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. Test apparatus used.
d. Area served.
e. Air-terminal-device make.
f. Air-terminal-device number from system diagram.
g. Air-terminal-device type and model number.
h. Air-terminal-device size.
i. Air-terminal-device effective area in sq. ft.
2. Test Data (Indicated and Actual Values):
a. Maximum and Minimum Airflow rates in cfm.
b. Air velocities in fpm.
c. Preliminary airflow rate as needed in cfm.
d. Preliminary velocity as needed in fpm.
e. Final airflow rates in cfm.
f. Final velocities 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. Compressor and Condenser Reports: For refrigerant side of unitary systems, and air-cooled condensing units include the following:
1. Unit Data:
   a. Unit identification.
   b. Location.
   c. Unit make and model number.
   d. Compressor make.
   e. Compressor model and serial numbers.
   f. Refrigerant weight in lb.
   g. Low ambient temperature cutoff in deg F.
2. Test Data (Indicated and Actual Values):
   a. Inlet-duct static pressure in inches wg.
   b. Outlet-duct static pressure in inches wg.
   c. Entering-air, dry-bulb temperature in deg F.
   d. Leaving-air, dry-bulb temperature in deg F.
   e. Control settings.
   f. Unloader set points.
   g. Low-pressure-cutout set point in psig.
   h. High-pressure-cutout set point in psig.
   i. Suction pressure in psig.
   j. Suction temperature in deg F.
   k. Condenser refrigerant pressure in psig.
   l. Condenser refrigerant temperature in deg F.
   m. Oil pressure in psig.
   n. Oil temperature in deg F.
   o. Voltage at each connection.
   p. Amperage for each phase.
   q. Kilowatt input.
   r. Crankcase heater kilowatt.

L. 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 and serial numbers.
   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.

M. Sound Measurement Reports: Record sound measurements on octave band and dBA test forms and on an NC or RC chart indicating the decibel level measured in each frequency band for both "background" and "HVAC system operating" readings. Record each tested location on a separate NC or RC chart. Record the following on the forms:
1. Date and time of test. Record each tested location on its own NC curve.
2. Sound meter manufacturer, model number, and serial number.
3. Space location within the building including floor level and room number.
4. Diagram or color photograph of the space showing the measurement location.
5. Time weighting of measurements, either fast or slow.
6. Description of the measured sound: steady, transient, or tonal.
7. Description of predominant sound source.

N. Instrument Calibration Reports:
1. Report Data:
a. Instrument type and make.
b. Serial number.
c. Application.
d. Dates of use.
e. Dates of calibration.

3.17 INSPECTIONS

A. Initial Inspection:
1. After testing and balancing are complete, operate each system and randomly check measurements to verify that the system is operating according to the final test and balance readings documented in the Final Report.
2. Randomly check the following for each system:
a. Measure airflow of at least 10 percent of air outlets.
b. Measure water flow of at least 5 percent of terminals.
c. Measure room temperature at each thermostat/temperature sensor. Compare the reading to the set point.
d. Measure sound levels at two locations.
e. Verify that balancing devices are marked with final balance position.
f. Note deviations to the Contract Documents in the Final Report.

B. Final Inspection:
1. After initial inspection is complete and evidence by random checks verifies that testing and balancing are complete and accurately documented in the final report, request that a final inspection be made by Owner.
2. TAB firm test and balance engineer shall conduct the inspection in the presence of Owner.
3. Owner shall randomly select measurements documented in the final report to be rechecked. The 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 8-hour business day.
4. If the 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."
5. 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.
6. TAB firm shall recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes and resubmit the final report.
7. Request a second final inspection. If the second final inspection also fails, Owner shall contract the services of another TAB firm to complete the testing and balancing in accordance with the Contract Documents and deduct the cost of the services from the final payment.

3.18 COMMISSIONING

A. Most of the mechanical systems are included in the Commissioning Program. Refer to the following specification sections for requirements associated with Commissioning:
1. Section 019113 “General Commissioning Requirements”.
2. Section 230800 “Commissioning of Mechanical Systems”.

3.19 ADDITIONAL TESTS

A. Within 90 days of completing TAB, perform additional testing and balancing to verify that balanced conditions are being maintained throughout and to correct unusual conditions. Owner shall randomly select measurements to be rechecked. The 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 8-hour business day.

B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional testing, inspecting, and adjusting during near-peak summer and winter conditions.

C. Air Measuring System Calibration Check: Compare transmitter output to traverse for Pitot tube and differential pressure probe transmitters every 6 months throughout the warranty period.

END OF SECTION

SECTION 230700 – MECHANICAL INSULATION

PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes mechanical insulation for boiler breeching, duct, equipment, and pipe, including the following:

1. Insulation Materials:

    a. Cellular glass.
    b. Flexible elastomeric.
    c. Mineral fiber.
    d. Polyisocyanurate.

2. Fire-rated insulation systems.
3. Insulating cements.
4. Adhesives.
5. Mastics.
6. Lagging adhesives.
7. Sealants.
8. Factory-applied jackets.
9. Field-applied fabric-reinforcing mesh.
10. Field-applied cloths.
11. Field-applied jackets.
12. Tapes.
13. Securements.
14. Corner angles.

B. Related Sections include the following:

1. Division 23 Section "Metal Ducts" for duct liners.
2. Division 01 Section “Sustainable Design Requirements – LEED for New Construction and Major Renovations” for additional requirements.
3. Division 23 Section “Hangers and Supports for HVAC Piping and Equipment” for Thermal-hanger shield inserts.

1.3 DEFINITIONS

A. ASJ: All-service jacket.

B. FSK: Foil, scrim, Kraft paper.

C. FSP: Foil, scrim, polyethylene.

D. PVDC: Polyvinylidene chloride.

E. SSL: Self-sealing lap.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated, identify thermal conductivity, thickness, and jackets (both factory and field applied, if any).

B. Shop Drawings: Show details for the following:

1. Application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
2. Insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
3. Removable insulation at piping specialties, equipment connections, and access panels.
4. Removable insulation at pumps.
5. Application of field-applied jackets.
6. Application at linkages of control devices.
7. Field application for each equipment type.

C. Installer Certificates: Signed by Contractor certifying that installers comply with requirements.

D. 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.

E. Field quality-control inspection 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. Fire-Test-Response Characteristics: Insulation and related materials shall have fire-test-response characteristics indicated, as determined by testing identical products per ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, and cement material containers, with appropriate markings of applicable testing and inspecting agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

C. Insulation materials shall be tested and rated according to ASTM Test Method C-177 to determine k-factors.

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.

B. Protect all insulating materials from dirt, water and damage during storage and installation. Remove damaged, wet or otherwise unsatisfactory insulation at Architect's direction.

1.7 COORDINATION

A. Coordinate size and location of supports, hangers, and insulation shields specified in Division 23 Section "Hangers and Supports for Mechanical Piping and Equipment."

B. Coordinate clearance requirements with piping Installer for piping insulation application, duct Installer for duct insulation application, and equipment Installer for equipment insulation application. Before preparing piping and 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, where applicable.

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.

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

2.2 INSULATION MATERIALS

A. Refer to Part 3 schedule articles for requirements about 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. Products:

   a. Industrial Insulation Group is a merger between Calsilite Group and Johns Manville.
   b. Industrial Insulation Group (The); Thermo-12 Gold.

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. Maximum K-Factor: 0.41 at 200 deg F. mean temperature.
5. 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 Part 2 "Factory-Applied Jackets" Article.

1. Products:

   a. Cell-U-Foam Corporation; Ultra-CUF.
   b. Pittsburgh Corning Corporation; Foamglas Super K.
   c. Specialty Products & Insulation Company (SPI); Lancaster, PA.

2. Preformed Pipe Insulation with Factory-Applied ASJ-SSL: Comply with ASTM C 552, Type II, Class 2.
3. Maximum K-Factor: 0.35 at 75 deg. F. mean temperature.
4. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.

H. Flexible Elastomeric: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials. Closed-cell polyolefin/polyethylene insulation is not acceptable as a substitution for ASTM C534 closed-cell rubber materials.

1. Products:

   a. Aeroflex USA Inc.; Aerocel.
   b. Armacell LLC; AP Armaflex.
   c. Nomaco K-Flex; Insul-Sheet and Insul-Tube 180.

2. Maximum K-Factor: 0.28 at 75 deg. F. mean temperature.

I. 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 III with factory-applied FSK jacket. Factory-applied jacket requirements are specified in Part 2 "Factory-Applied Jackets" Article.

1. Products:

    a. CertainTeed Corp.; Duct Wrap.
    b. Johns Manville; Microlite.
    c. Knauf Insulation; Duct Wrap.
    d. Owens Corning; All-Service Duct Wrap.

2. Maximum K-Factor: 0.24 at 75 deg. F. and material thickness compressed 25%.
3. Minimum Density: 1.5 pounds per cubic foot.

J. High-Temperature, Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type V, without factory-applied jacket.
   1. Products:
      a. Johns Manville; HTB 23 Spin-Glas.
      b. Owens Corning; High Temperature Flexible Batt Insulations.
   2. Maximum K-Factor: 0.23 at 75 deg. F.
   3. Minimum Density: 2.0 pounds per cubic foot.

K. 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 with factory-applied FSK jacket. For equipment applications, provide insulation with factory-applied ASJ. Factory-applied jacket requirements are specified in Part 2 "Factory-Applied Jackets" Article.

   1. Products:

      a. CertainTeed Corp.; Commercial Board.
      b. Johns Manville; 800 Series Spin-Glas, Type 814.
      c. Knauf Insulation; Insulation Board.
      d. Owens Corning; Fiberglas 700 Series.

   2. Maximum K-Factor: 0.23 at 75 deg. F. mean temperature.
   3. Minimum Density: 3.0 pounds per cubic foot.

L. High-Temperature, Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type III, without factory-applied jacket.
   1. Products:
      a. Johns Manville; 1000 Series Spin-Glas.
      b. Owens Corning; High Temperature Industrial Board Insulations.
      c. Rock Wool Manufacturing Company; Delta Board.
   2. Maximum K-Factor: 0.23 at 75 deg. F mean temperature; 0.33 at 300 deg. F mean temperature.
   3. Minimum Density: 3.0 pounds per cubic foot.

M. Mineral-Fiber, Preformed Pipe Insulation:

   1. Products:

      a. Johns Manville; Micro-Lok.
      b. Knauf Insulation; 1000 (Pipe Insulation).
      c. Owens Corning; Fiberglas Pipe 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, with factory-applied ASJ-SSL. Factory-applied jacket requirements are specified in Part 2 "Factory-Applied Jackets" Article.
3. Maximum K-Factor: 0.23 at 75 deg. F mean temperature; 0.34 at 250 deg. F mean temperature.

N. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied ASJ complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Factory-applied jacket requirements are specified in Part 2 "Factory-Applied Jackets" Article.

1. Products:

   a. CertainTeed Corp.; CrimpWrap.
   b. Johns Manville; MicroFlex.
   c. Knauf Insulation; Pipe and Tank Insulation.
   d. Owens Corning; Fiberglas Pipe and Tank Insulation.

2. Maximum K-Factor: 0.24 at 75 deg. F mean temperature; 0.39 at 300 deg. F mean temperature.
3. Minimum Density: 2.5 pounds per cubic foot.

O. Polyisocyanurate: Unfaced, preformed, rigid cellular polyisocyanurate material intended for use as thermal insulation.

1. Products:

   a. Apache Products Company; ISO-25.
   b. Dow Chemical Company (The); Trymer 2000.
   c. Duna USA Inc.; Corafoam.
   d. Elliott Company; Elfoam.

2. Comply with ASTM C 591, Type I or Type IV, except thermal conductivity (k-value) shall not exceed 0.19 Btu x in./h x sq. ft. x deg F at 75 deg F after 180 days of aging.
3. Flame-spread index shall be 25 or less and smoke-developed index shall be 50 or less for thickness up to 1-1/2 inches as tested by ASTM E 84.
4. Fabricate shapes according to ASTM C 450 and ASTM C 585.
5. Factory-Applied Jacket: Requirements are specified in Part 2 "Factory-Applied Jackets" Article.

   a. Pipe Applications: ASJ-SSL, (for all duty except cold service in unconditioned areas) PVDC-SSL (for cold service in unconditioned areas).
   b. Equipment Applications: ASJ-SSL, (for all duty except cold service in unconditioned areas) PVDC-SSL (for cold service in unconditioned areas).

2.3 INSULATING CEMENTS

A. Materials shall comply with LEED Credits EQ 4.1 and 4.2 for low emitting materials.

B. Mineral-Fiber Insulating Cement: Comply with ASTM C 195 and Division 1 Section “Sustainable Design Requirements”.

1. Products:

   a. Insulco, Division of MFS, Inc.; Triple I.
   b. P. K. Insulation Mfg. Co., Inc.; Super-Stik.

C. Expanded or Exfoliated Vermiculite Insulating Cement: Comply with ASTM C 196.

1. Products:

   a. P. K. Insulation Mfg. Co., Inc.; Thermal-V-Kote.

D. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449/C 449M.

1. Products:

   a. Insulco, Division of MFS, Inc.; SmoothKote.
   b. P. K. Insulation Mfg. Co., Inc.; PK No. 127, and Quik-Cote.
   c. Rock Wool Manufacturing Company; Delta One Shot.

2.4 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. Materials shall comply with LEED Credits EQ 4.1 and 4.2 for low emitting materials.

C. Calcium Silicate Adhesive: Fibrous, sodium-silicate-based adhesive with a service temperature range of 50 to 800 deg F.

1. Products:
   a. Childers Products, Division of ITW; CP-97.
   b. Foster Products Corporation, H. B. Fuller Company; 81-27/81-93.
   c. Marathon Industries, Inc.; 290.
   d. Mon-Eco Industries, Inc.; 22-30.
   e. Vimasco Corporation; 760.

D. Cellular-Glass and Polyisocyanurate Adhesive: Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300 deg F.

1. Products:

   a. Childers Products; CP-96.
   b. Foster Products Corporation, H. B. Fuller Company; 81-33/81-84.

E. Flexible Elastomeric Adhesive.

1. Products:

   a. Armacell LCC; 520 BLV Adhesive.
   b. Foster Products Corporation, H. B. Fuller Company; 85-75.
   c. Childers Products; CP-82.

F. Mineral-Fiber Adhesive.

1. Products:

a. Childers Products; CP-82/CP-127.
b. Foster Products Corporation, H. B. Fuller Company; 85-20/85-60.
c. ITW TACC, Division of Illinois Tool Works; S-90/80.
d. Mon-Eco Industries, Inc.; 22-68.

G. ASJ and FSK Adhesive: for bonding insulation jacket lap seams and joints.

1. Products:

a. Childers Products; CP-82.
b. Foster Products Corporation, H. B. Fuller Company; 85-20/85-60.
c. ITW TACC, Division of Illinois Tool Works; S-90/80.
d. Mon-Eco Industries, Inc.; 22-68.

H. PVC Jacket Adhesive: Compatible with PVC jacket.

1. Products:

a. Dow Chemical Company (The); 739, Dow Silicone.
b. Red Devil, Inc.; Celulon Ultra Clear.
c. Speedline Corporation; 73-20 RTV Adhesive/Sealant.

2.5 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates.

B. Materials shall comply with LEED Credits EQ 4.1 and 4.2 for low emitting materials.

C. Vapor-Barrier Mastic: Water based; suitable for indoor and outdoor use on below ambient services.

1. Products:

a. Childers Products; CP-34.
b. Foster Products Corporation, H. B. Fuller Company; 30-65.
c. ITW TACC, Division of Illinois Tool Works; CB-50.
d. Marathon Industries, Inc.; 590.
e. Mon-Eco Industries, Inc.; 55-40.
f. Vimasco Corporation; 749.

2. Water-Vapor Permeance: ASTM F 1249, 0.08 perm at 45-mil dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F.
4. Solids Content: ASTM D 1644, 48 percent by volume and 62 percent by weight.
5. Color: White.

D. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.

1. Products:

   a. Childers Products; CP-10/CP-11.
   b. Foster Products Corporation, H. B. Fuller Company; 35-00/46-50.
   c. ITW TACC, Division of Illinois Tool Works; CB-05/15.
   d. Marathon Industries, Inc.; 550.
   e. Mon-Eco Industries, Inc.; 55-50.
   f. Vimasco Corporation; WC-1/WC-5.

2. Water-Vapor Permeance: ASTM F 1249, 1-3 perms at 0.0625-inch dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F.
4. Solids Content: 51 percent by volume and 64 percent by weight.
5. Color: White.

2.6 LAGGING ADHESIVES

A. Materials shall comply with LEED Credits EQ 4.1 and 4.2 for low emitting materials.

B. Description: Shall be compatible with insulation materials, jackets, and substrates.

1. Products:

   a. Childers Products; CP-50AMV1.
   b. Foster Products Corporation, H. B. Fuller Company; 30-36.
   c. Marathon Industries, Inc.; 130.
   d. Mon-Eco Industries, Inc.; 11-30.
   e. Vimasco Corporation; 136.

2. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over duct, equipment, and pipe insulation.
3. Service Temperature Range: 0 to plus 180 deg F.
4. Color: White.

2.7 SEALANTS

A. Materials shall comply with LEED Credits EQ 4.1 and 4.2 for low emitting materials.

B. Joint Sealants:

1. Joint Sealants for Cellular-Glass and Polyisocyanurate Products:

   a. Childers Products; CP-76/CP-70.
   b. Foster Products Corporation, H. B. Fuller Company; 95-50/30-45.
   c. Marathon Industries, Inc.; 405.
   d. Mon-Eco Industries, Inc.; 44-05.
   e. Pittsburgh Corning Corporation; Pittseal 444.
   f. Vimasco Corporation; 750.

2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Permanently flexible, elastomeric sealant.
4. Service Temperature Range: Minus 100 to plus 300 deg F.
5. Color: White, tan, or gray.

C. FSK and Metal Jacket Flashing Sealants:

1. Products:

   a. Childers Products; CP-76.
   b. Foster Products Corporation, H. B. Fuller Company; 95-44.
   c. Marathon Industries, Inc.; 405.
   d. Mon-Eco Industries, Inc.; 44-05.
   e. Vimasco Corporation; 750.

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.

D. ASJ Flashing Sealants and PVC Jacket Flashing Sealants:

1. Products:

   a. Childers Products; 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.

2.8 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.

2.9 FIELD-APPLIED FABRIC-REINFORCING MESH

A. Materials shall comply with LEED Credits EQ 4.1 and 4.2 for low emitting materials.

B. Woven Glass-Fiber Fabric for Pipe Insulation: Approximately 2 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. inch for covering pipe and pipe fittings.

1. Products:

   a. Childers Products; Chil-Glas #10.
   b. Vimasco Corporation; Elastafab 894.

C. Woven Glass-Fiber Fabric for Duct and Equipment Insulation: Approximately 4 oz./sq. yd. with a thread count of 5 strands by 5 strands/sq. inch for covering equipment.

1. Products:

    a. Childers ProductsChil-Glas No. 5.

D. Woven Polyester Fabric: Approximately 1 oz./sq. yd with a thread count of 10 strands by 10 strands/sq. inch, in a Leno weave, for duct, equipment, and pipe.

1. Products:
    a. Foster Products Corporation, H. B. Fuller Company; Mast-A-Fab.
    b. Vimasco Corporation; Elastafab 894.

2.10 FIELD-APPLIED CLOTHS

A. Materials shall comply with LEED Credits EQ 4.1 and 4.2 for low emitting materials.

B. Woven Glass-Fiber Fabric: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 8 oz./sq. yd.

1. Products:

    a. Alpha Associates, Inc.; Alpha-Maritex 84215 and 84217/9485RW, Luben 59.

2.11 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

B. Materials shall comply with LEED Credits EQ 4.1 and 4.2 for low emitting materials.

C. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; 20 mil thickness; roll stock ready for shop or field cutting and forming.

1. Products:

    a. Johns Manville; Zeston.
    b. P.I.C. Plastics, Inc.; FG Series.
    c. Proto PVC Corporation; LoSmoke.
    d. Speedline Corporation; SmokeSafe.

2. Adhesive: As recommended by jacket material manufacturer.

3. Color: Color-code jackets based on system. Color selected to comply with University standards.

4. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.

    a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps and mechanical joints minimum 20 mil thickness.

5. Factory-fabricated tank heads and tank side panels.

D. Metal Jacket:

1. Products:

a. Childers Products; Metal Jacketing Systems.
b. PABCO Metals Corporation; Surefit.
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.
b. Thickness: 0.024 inch minimum.
c. Finish: Stucco-embossed finish.
d. Moisture Barrier for Indoor Applications: 1-mil- thick, heat-bonded polyethylene and Kraft paper.
e. Moisture Barrier for Outdoor Applications: 2.5-mil- thick Polysurlyn.
f. Factory-Fabricated Fitting Covers:

(1) Same material, finish, and thickness as jacket.
(2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
(3) Tee covers.
(4) Flange and union covers.
(5) End caps.
(6) Beveled collars.
(7) Valve covers.
(8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

E. Self-Adhesive Outdoor Jacket: 60-mil- thick, laminated vapor barrier and waterproofing membrane for installation over rigid insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a crosslaminated polyethylene film covered with stucco-embossed aluminum-foil facing.
1. Products:
a. MFM Building Products Corp., Flex Clad 400.
b. Polyguard; Alumaguard 60.
c. Venture Tape, VentureClad 1577

2.12 TAPES

A. Materials shall comply with LEED Credits EQ 4.1 and 4.2 for low emitting materials.

B. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136 and UL listed.

1. Products:

a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0835.
b. Compac Corp.; 104 and 105.
c. Ideal Tape Co., Inc., an American Biltrite Company; 428 AWF ASJ.
d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.

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.

C. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136 and UL listed.

1. Products:

   a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.
   b. Compac Corp.; 110 and 111.
   c. Ideal Tape Co., Inc., an American Biltrite Company; 491 AWF FSK.
   d. Venture Tape; 1525 CW, 1528 CW, and 1528 CW/SQ.

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.

D. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive. Suitable for indoor and outdoor applications.

1. Products:

   a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0555.
   b. Compac Corp.; 130.
   c. Ideal Tape Co., Inc., an American Biltrite Company; 370 White PVC tape.
   d. Venture Tape; 1506 CW NS.

2. Width: 2 inches.
3. Thickness: 6 mils.
4. Adhesion: 64 ounces force/inch in width.
5. Elongation: 500 percent.
6. Tensile Strength: 18 lbf/inch in width.

E. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive and UL listed.

1. Products:

   a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0800.
   b. Compac Corp.; 120.
   c. Ideal Tape Co., Inc., an American Biltrite Company; 488 AWF.
   d. Venture Tape; 3520 CW.
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.

2.13 SECUREMENTS

A. Materials shall comply with LEED Credits EQ 4.1 and 4.2 for low emitting materials.

B. Bands:

1. Products:

a. Childers Products; Bands.
b. PABCO Metals Corporation; Bands.
c. RPR Products, Inc.; Bands.

2. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 316; 0.015 inch thick, 3/4 inch wide with wing or closed seal.
3. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 3/4 inch wide with wing or closed seal.

C. Insulation Pins and Hangers:

1. 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.

a. Products:

(1) AGM Industries, Inc.; CWP-1.
(2) GEMCO; CD.
(3) Midwest Fasteners, Inc.; CD.
(4) Nelson Stud Welding; TPA, TPC, and TPS.

2. 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.

a. Products:

(1) AGM Industries, Inc.; CWP-1.
(2) GEMCO; Cupped Head Weld Pin.
(3) Midwest Fasteners, Inc.; Cupped Head.
(4) Nelson Stud Welding; CHP.

3. 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:
(1) GEMCO; Nylon Hangers.
(2) Midwest Fasteners, Inc.; Nylon Insulation Hangers.
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.

4. 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:

        (1) AGM Industries, Inc.; Tactoo Insul-Hangers, Series T.
        (2) GEMCO; Perforated Base.
        (3) Midwest Fasteners, Inc.; Spindle.

    b. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
    c. Spindle: Copper- or zinc-coated, low carbon steel, fully annealed, 0.106-inch-diameter shank, length to suit depth of insulation indicated.
    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. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- thick, galvanized-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:

        (1) AGM Industries, Inc.; RC-150.
        (2) GEMCO; R-150.
        (3) Midwest Fasteners, Inc.; WA-150.
        (4) Nelson Stud Welding; Speed Clips.

    b. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.

D. Staples: Outward-clinching insulation staples, nominal 3/4-inch- wide, stainless steel or Monel.

E. Wire: 0.062-inch soft-annealed, stainless steel.

1. Manufacturers:

    a. ACS Industries, Inc.
    b. C & F Wire.
    c. Childers Products.
    d. PABCO Metals Corporation.
    e. RPR Products, Inc.

2.14 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 316.

PART 3 EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation and other conditions affecting performance of insulation application.

1. Verify that systems and equipment to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.
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. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.3 COMMON INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment, ducts and fittings, and piping including fittings, valves, and specialties.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of equipment, duct system, and 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. Install insulation continuously through hangers and around anchor attachments.

K. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at 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.

L. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

M. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch- wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.
   a. For below ambient services, apply vapor-barrier mastic over staples.
4. Cover joints and seams with tape as recommended by insulation material manufacturer to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct and pipe flanges and fittings.

N. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

O. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

P. 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.

Q. Replace insulation on new and existing piping, ductwork and equipment where insulation is damaged during construction or removed for testing and balancing work.

R. 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. Handholes.
5. Cleanouts.
6. Unions.
7. Heating water strainers (1-inch and less).
8. Flanges
9. Expansion joints.
10. Heating water valves (1-inch and less).

3.4 PENETRATIONS

A. 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.

B. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

C. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions. 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.

D. Insulation Installation at Floor Penetrations:

1. Duct: Install insulation continuously through floor penetrations that are not fire rated. 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. Pipe: Install insulation continuously through floor penetrations.

3.5 DUCT AND PLENUM INSULATION INSTALLATION

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. Protect exposed corners with secured corner angles.
4. Install either capacitor-discharge-weld pins and speed washers or cupped-head, 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.

3.6 EQUIPMENT, TANK, AND VESSEL INSULATION INSTALLATION

A. Secure insulation with adhesive and anchor pins and speed washers.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of tank and vessel surfaces.
2. Groove and score insulation materials to fit as closely as possible to equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joints. Stagger end joints.
3. Protect exposed corners with secured corner angles.
4. Install adhesively attached or self-sticking insulation hangers and speed washers on sides of tanks and vessels as follows:

   a. Do not weld anchor pins to ASME-labeled pressure vessels.
   b. Select insulation hangers and adhesive that are compatible with service temperature and with substrate.
   c. On tanks and vessels, maximum anchor-pin spacing is 3 inches from insulation end joints, and 16 inches o.c. in both directions.
   d. Do not overcompress insulation during installation.
   e. Cut and miter insulation segments to fit curved sides and domed heads of tanks and vessels.
   f. Impale insulation over anchor pins and attach speed washers.
   g. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

5. Secure each layer of insulation with stainless-steel or aluminum bands. Select band material compatible with insulation materials.
6. Where insulation hangers on equipment and vessels are not permitted or practical and where insulation support rings are not provided, install a girdle network for securing insulation. Stretch prestressed aircraft cable around the diameter of vessel and make taut with clamps, turnbuckles, or breather springs. Place one circumferential girdle around equipment approximately 6 inches from each end. Install wire or cable between two circumferential girdles 12 inches o.c. Install a wire ring around each end and around outer periphery of center openings, and stretch prestressed aircraft cable radially from the wire ring to nearest circumferential girdle. Install additional circumferential girdles along the body of equipment or tank at a minimum spacing of 48 inches o.c. Use this network for securing insulation with tie wire or bands.
7. Stagger joints between insulation layers at least 3 inches.
8. Install insulation in removable segments on equipment access doors, manholes, handholes, and other elements that require frequent removal for service and inspection.
9. Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.
10. For equipment with surface temperatures below ambient, apply mastic to open ends, joints, seams, breaks, and punctures in insulation.

B. Flexible Elastomeric Thermal Insulation Installation for Tanks and Vessels: Install insulation over entire surface of tanks and vessels.

1. Apply 100 percent coverage of adhesive to surface with manufacturer's recommended adhesive.
2. Seal longitudinal seams and end joints.

C. Insulation Installation on Pumps:

1. Fabricate removable, re-useable metal boxes lined with insulation. Fit boxes around pumps and coincide box joints with splits in pump casings. Covers for split case pumps shall be constructed with insulated housing in two sections with upper section removable for access to casing. Fabricate joints with outward bolted flanges. Bolt flanges on 6-inch centers, starting at corners. Install 3/8-inch- diameter fasteners with wing nuts. Alternatively, secure the box sections together using a latching mechanism.
2. Fabricate boxes from aluminum or stainless steel, at least 0.050 inch thick.
3. For below ambient services, install a vapor barrier at seams, joints, and penetrations. Seal between flanges with replaceable gasket material to form a vapor barrier.

3.7 GENERAL PIPE INSULATION INSTALLATION

A. Requirements in this Article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:

1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity, unless otherwise indicated.
2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below ambient services, provide a design that maintains vapor barrier.

6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below ambient services and a breather mastic for above ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
8. For services not specified to receive a field-applied jacket except for flexible elastomeric, 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, vessels, and equipment. 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. Provide non-compressible inserts at hanger and support locations for pipes 4” and larger.

E. 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.

3.8 CALCIUM SILICATE INSULATION INSTALLATION

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 2-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.

3.9 CELLULAR-GLASS INSULATION INSTALLATION

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 but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of cellular-glass 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.

3.10 FLEXIBLE ELASTOMERIC INSULATION INSTALLATION

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.

3.11 MINERAL-FIBER INSULATION INSTALLATION

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 but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
4. Install insulation to flanges as specified for flange insulation application.

E. 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 cupped-head, 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 1 edge and 1 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 (10 deg C) 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 2 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.

F. 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 cupped-head, 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 1 edge and 1 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 2 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.

3.12 POLYISOCYANURATE INSULATION INSTALLATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation to pipe with tape or bands and tighten without deforming insulation materials. Orient longitudinal joints between half sections in 3 and 9 o'clock positions on the pipe.
2. For insulation with factory-applied jackets with vapor barriers, do not staple longitudinal tabs but secure tabs with additional adhesive or tape as recommended by insulation material manufacturer and seal with vapor-barrier mastic.
3. All insulation shall be tightly butted and free of voids and gaps at all joints. Vapor barrier must be continuous. Before installing jacket material, install vapor-barrier system.

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, same thickness of adjacent pipe insulation, not to exceed 1-1/2-inch thickness.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polyisocyanurate block insulation of same thickness as pipe insulation.

C. Insulation Installation on Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of polyisocyanurate 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.

3.13 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 manufacturers 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.

E. Duct Sound Lagging:

1. Seal and fasten in accordance with manufacturer’s written instructions to maintain specified STC rating.
2. Overlap duct lagging minimum 2-inches at seams.
3. Do not compress insulation to solid.

3.14 FINISHES

A. Duct, Equipment, and Pipe Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Refer to Division 9 painting Sections.

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.

3.15 INSULATION APPLICATION SCHEDULE

A. Acceptable insulation materials, thickness and vapor retarder requirements are identified for each application and size range. If more than one material is listed for an application and size range, selection from the materials listed is Contractor’s option.

B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:

1. Below-grade piping.
2. Chrome-plated pipes and fittings unless there is a potential for personnel injury.
3. Exhaust ductwork.
4. Factory-insulated flexible ducts.
5. Factory-insulated plenums and casings.
6. Flexible connectors.
7. Vibration-control devices.
8. Factory-insulated access panels and doors.

C. Where metal ducts are specified to have internal duct liner, the thickness of the external insulation may be reduced by one inch.

D. Provide removable, replaceable insulation plugs at manufacturer’s equipment identification plates on insulated equipment.

SERVICE	INSULATION MATERIAL	INSULATION THICKNESS	VAPOR RETARDER REQUIRED
AIR CONDITIONING CONDENSATE DRAIN AND EQUIPMENT DRAIN PIPING; DOMESTIC AND NON-POTABLE WATER PIPING			
Interior, All sizes	Mineral Fiber; Flexible Elastomeric	1”	Yes
GLYCOL COOLING WATER SUPPLY AND RETURN PIPING			
Indoor Duty:			
All Sizes	Mineral Fiber	1-1/2”	Yes
OUTDOOR ABOVEGROUND GLYCOL COOLING WATER SUPPLY AND RETURN PIPING; OUTDOOR CONDENSATE DRAIN PIPING			
All Sizes	Cellular Glass	2”	Yes
All Sizes, Alternative Insulation	Flexible Elastomeric; or	2”	Yes

SERVICE	INSULATION MATERIAL	INSULATION THICKNESS	VAPOR RETARDER REQUIRED
Materials	Polyisocyanurate		
LOW PRESSURE STEAM HUMIDIFICATION PIPING			
Indoor Duty			
1¼” diameter and smaller	Mineral Fiber	2”	No
1½” diameter and larger	Mineral Fiber	3”	No
SUPPLY-AIR DUCTS AND PLENUMS			
Indoor Duty			
Concealed, Generally	Mineral-Fiber Blanket	1-1/2”	Yes
Exposed, Generally	Mineral-Fiber Board	1-1/2”	Yes
Equipment Rooms (Note 1)	Mineral-Fiber Board	2”	Yes
RETURN, RELIEF, AND EXHAUST-AIR DUCTS AND PLENUMS			
Indoor Duty			
In locations other than unconditioned space	None	--	--
Equipment Rooms (Note 1)	Mineral-Fiber Board	1-1/2”	Yes
EXPANSION TANKS AND AIR SEPARATORS	Mineral Fiber Board; or Mineral Fiber Pipe and Tank	2”	Yes

Notes:
1. Spaces include locations where summer temperature and humidity conditions are similar to outdoor conditions (such as mechanical rooms ventilated with tempered outdoor air, etc).
2. Where rigid pipe insulation (cellular glass, etc.) is scheduled, provide mineral fiber through and 6 inches beyond pipe sleeves to allow for pipe expansion.

3.16 FIELD APPLIED JACKET APPLICATION SCHEDULE

SERVICE	FIELD APPLIED JACKET TYPE
Indoor, exposed insulated piping within 8 feet of floor, for service temperatures 200 degrees F and below	PVC
Indoor, exposed insulated piping within 8 feet of floor, for service temperatures above 200 degrees F	Aluminum
Indoor, exposed insulated piping greater than 8 feet above floor, generally	None
Indoor, cold service piping greater than 8 feet above the floor, within spaces subject to outdoor temperature and humidity conditions (such as mechanical and electrical rooms ventilated with tempered outdoor air, etc.)	PVC
Indoor concealed piping	None
Outdoor exposed piping	Aluminum

SERVICE	FIELD APPLIED JACKET TYPE
Indoor, All Locations, Fittings and valves in piping systems at service temperatures 200 degrees F and below	Factory Fabricated PVC covers
Indoor, All Locations, Fittings and valves in piping systems at service temperatures above 200 degrees F	Aluminum
Outdoor, all locations, fittings and valves in piping systems	Aluminum
Indoor, exposed insulated ductwork within 8 feet of floor	Woven Glass Fiber Fabric
Indoor, exposed insulated ductwork greater than 8 feet above floor	None
Outdoor exposed ducts	Self-Adhesive Outdoor Jacket
Indoor concealed insulated ductwork	None
Equipment, generally (Notes 1 & 2)	Woven Glass Fiber Fabric
Equipment, cold surface (Notes 1 & 2)	PVC
Equipment for service temperatures above 200 degrees F, generally (Note 3)	Aluminum Jacket

Notes:
1. Refer to Part 3 specification section titled “Equipment Insulation Installation” for requirements for removable, re-usable metal boxes lined with insulation at pumps.
2. Including factory insulated equipment without factory applied jacket.
3. Provide removable, reusable insulation jackets for valves, traps and flow meters for steam and condensate piping systems.

END OF SECTION 230700

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.

B. Related Sections include the following:
   1. Section 23 05 19 “Meters and Gages for Mechanical Piping” for thermometers, gages, and thermowells.
   2. Section 23 36 00 “Air Terminal Units” for air terminal units to have factory installed controllers furnished under this Section.
   3. Section 23 09 01 “Air Measuring Stations” for air measuring stations and static pressure stations to be furnished under this section, installed under Section 23 31 13 “Metal Ducts”
   4. Most of the mechanical systems are included in the Commissioning Program. Refer to the following specification sections for requirements associated with Commissioning:
      a. Section 01 91 13 “General Commissioning Requirements”.

1.3 DEFINITIONS

A. Beneficial Use: Owner's operators are able to use the system and receive reliable information in their normal work schedules for inputs and outputs in the automation system network.

B. BAS: Building Automation System

C. DCP: Digital control panel.

D. DC: Direct-digital controls.

E. DPDT: Double-pole, double-throw.

F. DPST: Double-pole, single-throw.

G. LAN: Local area network.

H. PICS: Protocol Implementation Conformance Statement.

I. SPDT: Single-pole, double-throw.

J. SPST: Single-pole, single-throw.

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 Pressure: Plus or minus 2 percent of full scale.
      c. Space Temperature: Plus or minus 1 deg F.
      d. Ducted Air Temperature: Plus or minus 1 deg F.
      e. Outside Air Temperature: Plus or minus 2 deg F.
      f. Dew Point Temperature: Plus or minus 3 deg F.
      g. Temperature Differential: Plus or minus 0.25 deg F.
      h. Relative Humidity: Plus or minus 5 percent.
      i. Airflow (Measuring Stations): Plus or minus 5 percent of full scale.
      j. Airflow (Terminal): Plus or minus 10 percent of full scale.
      k. Air Pressure (Ducts): Plus or minus 0.1-inch wg.
      l. Carbon Dioxide: Plus or minus 50 ppm.
      m. Electrical: Plus or minus 5 percent of reading.

1.5 SYSTEM DESCRIPTION

A. Control system consists 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.

B. System shall be connected to the existing building and campus control system.

C. System shall include BACnet DDC protocol and connectivity to allow network connections for BAS network.

D. System Architecture:
   1. Minimum one primary controller with adequate resources and memory for input and output points to be trended on 1 minute intervals.
   2. Terminal controllers (VAV boxes, etc.) may reside on polling or peer-to-peer secondary network with maximum nodes and specified time response.

1.6 SUBMITTALS

A. System Interoperability Certification: Submit documentation that certifies proven capability of the new system to interface with the existing DDC System. Documentation shall provide a technical explanation of the system, and its ability to be part of a future campus building automation system upgrade.

B. 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. Each control device labeled with setting or adjustable range of control.

C. 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. Schematic flow diagrams showing fans, pumps, coils, dampers, valves, and control devices.
   2. Wiring Diagrams: Power, signal, and control wiring. Differentiate between manufacturer-installed and field-installed wiring.
   3. Details of control panel faces, including controls, instruments, and labeling.
   4. Written description of sequence of operation.
   5. Schedule of dampers including size, leakage, pressure drop, and flow characteristics.
   6. Schedule of valves including size, leakage, pressure drop, and flow characteristics.
   7. Trunk cable schematic showing programmable control unit locations and trunk data conductors.
   8. Listing of connected data points, including connected control unit and input device.
   9. System graphics indicating monitored systems, data (connected and calculated) point addresses, and operator notations.
   10. System configuration showing peripheral devices, batteries, power supplies, diagrams, modems, and interconnections.
   11. Settings of control devices.
   12. Lists of proposed devices and equipment for each system drawing.
   13. Calculations for sizing valves, dampers, and actuators.
   14. Floor plans indicating locations of zone sensors.

D. Data Communications Protocol Certificates (one of the following):
   1. Certify that each proposed DDC system component complies with ASHRAE 135 (BACNet).

E. Samples: For each color required, of each type of thermostat cover.

F. 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.

G. Software Upgrade Kit: For Owner to use in modifying software to suit future power system revisions or monitoring and control revisions.

H. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

I. Maintenance Data: For systems to include in maintenance manuals specified in Division 01. Include the following:
1. Maintenance instructions and lists of spare parts for each type of control device.
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.
6. Start-up, normal, and emergency operating procedures.
7. Names, addresses, and phone numbers of equipment suppliers, subcontractors, and manufacturer’s field representatives.
8. List of parts required for one year of continuous operation. Include parts numbers and names, addresses, and phone numbers of supply sources.

J. Qualification Data: For firms and persons specified in "Quality Assurance" Article.

K. Project Record Documents: Record actual locations of control components, including control units, thermostats, and sensors. Revise Shop Drawings to reflect actual installation and operating sequences. Provide DCP data file construction including point processing assignments, physical terminal relationships, scales and offsets, command and alarm limits, etc.

L. Documentation of instruments and sensors field calibration.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: An experienced installer who is an authorized representative of the automatic control system manufacturer for both installation and maintenance of units required for this Project.

B. Manufacturer Qualifications: A firm experienced in manufacturing automatic temperature-control systems similar to those indicated for this Project and with a record of successful in-service performance.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

D. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilation Systems."

E. Comply with ASHRAE 135 or LonWorks for DDC system control components.

F. Comply with ANSI B16.104, “Quality Control Standard for Control Valve Seat Leakage.”

1.8 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 unit manufacturer.

1.9 COORDINATION

A. Coordinate location of thermostats, humidistats, and other exposed control sensors with plans and room details before installation.
   1. Self-timers for mechanical systems shall not be located in noise critical spaces.

B. Coordinate supply of conditioned electrical circuits for control units and operator workstation.

C. Coordinate equipment with Section 26 24 16 "Panelboards" to achieve compatibility with starter coils and annunciation devices.

D. Coordination with Commissioning Agent:
   1. Attend a sequence coordination meeting with engineer, CxA, and contractors to review sequences before software programming.
   2. Furnish a full operational graphic interface (laptop) for use at the new building prior to commissioning. This may be the Mobile Operator Station.
   3. ATC Contractor shall provide a minimum of one dedicated controls technician during the functional performance testing of all building systems controlled, monitored or interfaced with the ATC system. This individual shall be familiar with the programming and control sequences. During the functional testing period this technician shall have no other assigned responsibilities except to work with the Commissioning Agent.
   4. Should the technician assigned to work with the Commissioning Agent not be available at the time of testing of a system or piece of equipment, the ATC Contractor shall provide a substitute technician of equal qualifications to work during this period.
   5. ATC Contractor shall be responsible for any and all costs incurred by other parties due to the non-availability of a qualified technician.

1.10 WARRANTY

A. Special Warranty: During the warranty period the entire system shall be kept in proper operating condition and serviced at no additional cost to the Owner.

B. Special Warranty: Corrective software modifications made during warranty service periods shall be updated on user documentation and on user and manufacturer archived software disks.

1.11 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.

B. Maintenance Materials: One set of any special tools required for operation, adjustment, resetting, or maintenance.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Control Systems Components: As indicated in product articles.
   2. Electric, Electronic, and DDC Systems:

a. Delta.

2.2 DDC EQUIPMENT

A. Application Software: Include the following:
1. Input/output capability from operator station.
2. Operator system access levels via software password.
3. Database creation and support.
4. Dynamic Color Graphic Displays: Color graphic floor plan displays, and system schematics for each piece of mechanical equipment, including air handling units, chilled water systems, and hot water systems, shall be provided as noted by the I/O Summary Sheets specified in Section 23 09 93 "Sequence of Operations for HVAC Controls". Points in the system shall be included in at least one dynamic graphic.
   a. System Selection/Penetration: The operator interface shall allow users to access the various system schematics and floor plans via a graphical penetration scheme, menu selection, or text-based commands.
   b. Data Displays: Dynamic temperature values, humidity values, flow values, and status indication shall be shown in their actual respective locations, and shall automatically update to represent current conditions without operator intervention.
   c. Windowing: The windowing environment of the PC Operator Workstation shall allow the user to simultaneously view several graphics at the same time to analyze total building operation, or to allow the display of a graphic associated with an alarm to be viewed without interrupting work in progress.
   d. VAV Summary Graphic: Tabular information of VAV's per AHU, including setpoints, room temperature, discharge temperature, damper position, airflow, reheat valve position, etc.
5. Alarm processing.
6. Event Processing: Detection and accommodation of single or multiple failures of either workstations, DDC panels or the network media. The network shall include provisions for automatically re-configuring itself to allow operational equipment to perform their designated functions as effectively as possible in the event of single or multiple failures.
7. Automatic restart of field equipment on restoration of power.
8. Data Collection:
   a. Message and alarm buffering to prevent information from being lost.
   b. Error detection, correction, and re-transmission to guarantee data integrity.
   c. Default device definition to prevent loss of alarms or data, and ensure alarms are reported as quickly as possible in the event an operator device does not respond.
   d. Extensive archiving of system configuration data, historical data, trend data, and operator actions. All data stored shall be through the use of a standard database platform.
   e. Trend and change of value data shall be stored with a network DDC engine and uploaded with a dedicated trend database or exported in a selectable data format via provided data export utility.
9. Graphic Development on Workstation: Graphic generation software shall be provided to allow the user to add, modify, or delete system graphic displays.
   a. The ATC System contractor shall provide libraries of pre-engineered screens and symbols depicting standard air handling unit components (e.g. fans, cooling coils, filters, dampers, etc.), complete mechanical systems (e.g. constant volume-terminal reheat, VAV, etc.) and electrical symbols.
   b. The graphic development package shall use a mouse or similar pointing device in conjunction with a drawing program to allow the user to perform the following:

define symbols; position and size symbols; define background screens; define connecting lines and curves; locate, orient and size descriptive text; define and display colors for all elements; and establish correlation between symbols or text and associated system points or other displays.

c. Graphical displays can be created to represent any logical grouping of system points or calculated data based upon building function, mechanical system, building layout, or any other logical grouping of points which aids the operator in the analysis of the facility. To accomplish this, the user shall be able to build graphic displays that include point data from multiple DDC panels, including application specific controllers. Graphical displays shall include, but not be limited to, the following:
   1) Floor Plan requirements:
      a) Major equipment locations
      b) Room temperatures
      c) Room RH% levels
      d) Fire damper locations and positions
      e) Combination fire and smoke damper locations and positions
      f) Lighting systems – all available info from the lighting control system, including scene number, lighting lumens, trouble, etc.
   2) System Schematic requirements:
      a) Air Handling Units (including BTUH calcs for various AHU components)
      b) Exhaust Fans and systems (including BTUH calcs for various energy recovery components)
      c) Chilled Water System
      d) Condenser Water System
      e) Heating Hot Water System
      f) Domestic Water System (including solar hot water system)
      g) Humidifiers
      h) Fan Coil Units
      i) Rainwater Harvesting System
      j) Sump Pumps
      k) Sewage Pumps
      l) Elevator Sump Pumps
   3) Generally, if equipment/systems are operating normally, they shall appear in a green color. If an alarm condition is present, the equipment/system shall appear in a red color.

10. Maintenance management – suggested equipment maintenance schedules, user-input equipment maintenance schedules, etc.

B. Control Units: Modular, multi-tasking, multi-user, comprising processor board with programmable, nonvolatile, random-access memory; local operator access and display panel; integral interface equipment; and backup UPS power source.
   1. Units monitor or control each input/output point; process information; execute commands from other control units, devices, and operator stations; and download from or upload to operator station.
   2. Stand-alone mode control functions operate regardless of network status. Functions include the following:
      a. Global communications.
      b. Discrete/digital, analog, and pulse input/output.
      c. Monitoring, controlling, or addressing data points.

d. Testing and developing control algorithms without disrupting field hardware and controlled environment.
e. Control processes.
f. Energy Management Applications.
g. Alarm Management.
h. Historical/Trend Data for points.
i. Maintenance Support Applications.
j. Custom Processes.
k. Operator I/O
l. Dial-Up Communications.
m. Manual Override Monitoring.

3. Point Types: Support the following types of point inputs and outputs without the addition of equipment outside the DDC panel:
   a. Digital Inputs for status/alarm contacts: Dry contract closure, pulse accumulator, and voltage sensing.
   b. Digital Outputs for on/off equipment control: Contact closure.
   c. Analog Inputs for temperature, pressure, humidity, flow, and position measurements: 4-20 Ma, 0-10 Vdc, Thermistors, and 1000 ohm RTD's.
   d. Analog Outputs for valve and damper position control, and capacity control of primary equipment: 4-20 mA, 0-10 Vdc, and pulse inputs for pulsed contact monitoring.
4. Point Quantity: provide adequate points on a single control unit to accomplish the sequences, plus 20% spare capacity for each point type, with minimums as follows:
   a. Five DI.
   b. Five DO.
   c. Two AI.
   d. Two AO.
5. Local operator interface provides for download from or upload to mobile operator station: Provide at least two RS-232C serial data communication ports for simultaneous operation of multiple operator I/O devices such as industry standard printers, laptop workstations, PC workstations, and panel mounted or mobile operator station. Standalone DDC panels shall allow temporary use of portable devices without interrupting the normal operation of permanently connected devices.
6. Local Status Indicator Lamps: Local status indication for each binary input and output for constant, up-to-date verification of point conditions without the need for an operator I/O device.
7. Integrated On-Line Diagnostics: Continuously perform self-diagnostics, communication diagnosis and diagnosis of subsidiary equipment. Both local and remote annunciation of any detected component failures, or repeated failure to establish communication. Indication of the diagnostic results shall be provided at each Control Unit, and shall not require the connection of an operator I/O device.
8. Surge and Transient Protection: Isolation shall be provided at network terminations, as well as field point terminations to suppress induced voltage transients consistent with IEEE Standard 587-1980. Isolation levels shall be sufficiently high as to allow signal wiring to be run in the same conduit as high voltage wiring where acceptable by electrical code.
9. Powerfail Restart: In the event of the loss of normal power, there shall be an orderly shutdown of Control Units to prevent the loss of database or operating system software. Non-Volatile memory shall be incorporated for critical controller configuration data, and battery back-up shall be provided to support the real-time clock and volatile memory for a minimum of 72 hours. Upon restoration of normal power, the DDC panel shall automatically resume full operation without manual intervention. Should memory be lost,

the panel will automatically receive a download via the local area network, phone lines, or connected computer. In addition, the user shall have the capability of reloading the Control Unit through the local area network, the local RS-232C port, or telephone line dial-in.

C. Local Control Units: Modular, multi-tasking, comprising processor board with electronically programmable, nonvolatile, read-only memory; and backup power source.
1. Units monitor or control each input/output point; process information; and download from or upload to operator station, PC, mobile operator station, or DDC panel in the network.
2. Units shall be able to extend performance and capacity through the use of remote Local Control Units.
3. Stand-alone mode control functions operate regardless of network status. Functions include the following:
a. Global communications.
b. Discrete/digital, analog, and pulse input/output.
c. Monitoring, controlling, or addressing data points.
d. Control processes.
e. Energy management applications.
f. Operator I/O.
4. Local operator interface provides for download from or upload to mobile operator station.
5. Units shall directly support the use of mobile operator station. The capabilities of the portable terminal shall include but not be limited to the following:
a. Display temperatures.
b. Display status.
c. Display setpoints.
d. Display control parameters.
e. Override binary output control.
f. Override analog setpoints.
g. Modification of gain and offset constants.
6. Power fail Protection: System setpoints, proportional bands, control algorithms, and any other programmable parameters shall be stored such that a power failure of any duration does not necessitate reprogramming the controller.

D. Variable Air Volume and Constant Volume Air Terminal Unit Controller/Damper Actuator Assembly (VMA): Provide for each air terminal unit (variable volume or constant volume supply), configurable, application specific DDC controller with integral pressure transducer and damper actuator (VMA) to perform the sequence of control described on the drawings for pressure-independent application and to provide monitoring and control functions listed in the I/O summary sheets at the end of Section23 09 93 “Sequence of Operations for HVAC Controls.”
1. Controllers/Actuators shall be electronic type, furnished under this Section, and shipped to the terminal unit manufacturer (specified under Section 23 36 00 “Air Terminal Units” for factory mounting.
2. The VMA shall provide both standalone and networked direct digital control:
a. Ability to download and upload VMA configuration files, both locally and via the communications network. Controllers shall be able to be loaded individually or as a group using a zone schedule generated spreadsheet of controller parameters.
b. Control setpoint changes initiated over the network shall be written to VMA non-volatile memory to prevent loss of setpoint changes and to provide consistent operation in the event of communication failure.
3. Components shall be connected and mounted as a single assembly that can be removed as one piece.

4. The integral damper actuator shall be a fast response stepper motor capable of stroking 90 degrees in 30 seconds for quick damper positioning.
5. The VMA shall determine airflow by dynamic pressure measurement using an integral dead-ended differential pressure transducer. The transducer shall be maintenance-free and shall not require air filters.
6. Automatically calibrate the flow sensor to eliminate pressure transducer offset error due to ambient temperature / humidity effects.
7. Utilize a proportional plus integration (PI) algorithm for the space temperature control loops.
8. Continuously, adaptively tune the control algorithms to improve control and controller reliability through reduced actuator duty cycle.
9. Provide fail-soft operation if the airflow signal becomes unreliable, by automatically reverting to a pressure-dependent control mode.
10. Interface with balancer tools that allow automatic recalculation of box flow pickup gain ("K" factor), and the ability to directly command the airflow control loop to the box minimum and maximum airflow setpoints.
11. Capable of direct electronic connection to the Alnor® DB150 Balometer™ balancing hood. Connection shall be through a port located on the room sensor. As an alternative, software balancing tools shall be provided that will run in a hand-held Personal Computer (such as the Apple Ipad or Android device). The balancing tools shall allow adjustment of airflow and temperature setpoints and parameters and provide permanent upload of the values entered to the VMA. The handheld device shall connect to the terminal unit through the room sensor port.
12. Performance shall be self-documenting via on-board diagnostics. Diagnostics shall consist of control loop performance measurements executing at each control loop's sample interval, which may be used to continuously monitor and document system performance.
13. Detect system error conditions to assist in managing the VAV zones.
14. Provide a flow test function to view damper position vs. flow in a graphical format. The information shall alert the user to check damper position. Provide a method to calculate actuator duty cycle as an indicator of damper actuator runtime.
15. Compatible with demand-based static pressure reset down to 2/3 of duct static pressure set point.
16. Inputs:
    a. Analog inputs with user-defined ranges shall monitor the following analog signals, without the addition of equipment outside the terminal controller cabinet: 0-10 VDC Sensors, 1000ohm RTDs, and NTC Thermistors.
    b. Binary inputs shall monitor dry contact closures
    c. Sideloop application for humidity control and monitoring.
17. Outputs
    a. Analog outputs shall provide the following control outputs: 0-10 VDC
    b. Binary outputs shall provide a SPST output rated for 500mA at 24 VAC.
18. Sensor Support: Space sensors specified herein, space sensors as defined by analog input requirements, carbon dioxide sensors, and humidity sensors defined by the AI sideloop.
19. Controller shall accurately control air flow quantity with a differential pressure signal of 0.03 inch wg.

E. LAN: DDC system shall tap into existing control system.

F. Software: Update to latest version of software at Project completion. Include and implement the following capabilities from the control units:
1. Units of Measure: Inch-pound and SI (metric).
2. Control Algorithms: Pre-tested two position control, proportional control, proportional plus integral control, and proportional, integral, plus derivative control.
3. Load Control Programs: Demand limiting, duty cycling, automatic time scheduling, start/stop time optimization, night setback/setup, DDC with fine tuning, calendar based scheduling, holiday scheduling, temporary schedule overrides, and trend logging.
4. HVAC Control Programs: Optimal run time, supply-air reset, fan speed/CFM control, heating/cooling interlock, hot water reset, supply air temperature reset, duct static pressure reset, and enthalpy switchover.
    a. Programs shall be executed automatically without the need for operator intervention, and shall be flexible enough to allow operator customization.
5. Chiller Control Programs: Control function of condenser water reset, chilled-water reset, and equipment sequencing.
6. Programming Application Features: Include trend point, alarm messages, weekly scheduling, and interlocking.

G. Data Control:
1. Provide all hardware devices required to be connected to the remote electronic panels, and the standard control software modules to be implemented. In addition, additional hardware and software required to accomplish the detailed sequence of operations specified shall be provided. The following also includes pseudo points required to be provided for display in logical groups and graphics. Commandable pseudo points shall be commandable directly from displays.
2. Each analog point shall have unique remote panel resident dual high and dual low limit alarm thresholds. Where specified, floating (a band above and below a setpoint) alarm limits shall be provided.
3. Each digital output shall have a software-associated monitored input. Any time the monitored input does not track it's associated command output within a programmable time interval, a "command failed" alarm shall be reported.
4. Where calculated points such as CFM are shown, they shall appear in their respective logical groups. The respective unconditioned raw data (such as the logarithmic differential pressure) points shall also be grouped in a special group for display and observation independent of the logical groups.
5. Unless otherwise specified or approved prior to bidding, the primary analog input and the analog output of each DDC loop shall be resident in a single remote panel containing the DDC algorithm, and shall function independent of any peer or mux communication links. Secondary (reset type) analog inputs may be received from the peer network, but approved default values and/or procedures shall be substituted in the DDC algorithm for this secondary input if network communications fail or if the secondary input becomes erroneous or invalid.

2.3 CONTROL PANELS

A. Local Control Panels: 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 0.06-inch- thick, furniture-quality steel, or extruded-aluminum alloy, totally enclosed, with hinged doors and keyed lock and with manufacturer's standard shop-painted finish.

2. Panel-Mounted Equipment: Temperature and humidity controllers, relays, and automatic switches; except safety devices. Mount devices with adjustments accessible through front of panel.
3. Door-Mounted Equipment: Flush-mount (on hinged door) manual switches, including damper-positioning switches, changeover switches, thermometers, and gages.
4. Graphics: Color-coded graphic, laminated-plastic displays on doors, schematically showing system being controlled, with protective, clear plastic sheet bonded to entire door.
5. Isolate low voltage and line voltage terminals.

2.4 SENSORS

A. Electronic Sensors: Vibration and corrosion resistant; for wall, immersion, or duct mounting as required.
   1. Thermistor Temperature Sensors: 10,000 ohm at 77 deg F; lead wires terminated on enclosed terminal block.
      a. Accuracy: Plus or minus 0.4 deg F from 0 to 70 deg F.
      b. Wire: Twisted, shielded-pair cable.
      c. 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. Do not use insertion sensors where sensor is less than 72-inches downstream of heating or cooling coils.
      d. Averaging Elements in Ducts: Minimum 72 inches long, flexible; use where prone to temperature stratification or where ducts are larger than 9 sq. ft.; length as required. Averaging sensors shall be used where sensors are installed within 72-inches downstream of heating or cooling coils.
      e. Insertion Elements for Liquids: Minimum insertion length of 2-1/2 inches, stainless steel well.
      f. Room Sensors: Locking cover; element terminated on clamp type connectors or plug-in strip; plug-in communications jack, insulated base for mounting on exterior walls.
         1) For room sensors in offices and conference rooms provide sensors with push button for over-ride of unoccupied functions; display of space temperature and setpoint; and occupant temperature setpoint adjustment.
         2) For room sensors in classrooms and instructional area, provide only push button for over-ride of unoccupied functions
         3) For room sensors in all other spaces, room sensors shall have no additional features, other than sensing space temperature.
      g. Outside-Air Sensors: Watertight inlet fitting, shielded from direct sunlight.
   2. Resistance Temperature Detectors (RTD): Platinum, lead wires terminated on enclosed terminal block.
      a. Accuracy: Plus or minus 0.4 deg F of range (20 deg F to 120 deg F or 70 deg F to 220 deg F).
      b. Wire: Twisted, shielded-pair cable.
      c. 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. Do not use insertion sensors where sensor is less than 72-inches downstream of heating or cooling coils.
      d. Averaging Elements in Ducts: Minimum 72 inches long, flexible; use where prone to temperature stratification or where ducts are larger than 9 sq. ft.; length as

required. Averaging sensors shall be used where sensors are installed within 72-inches downstream of heating or cooling coils.

e. Insertion Elements for Liquids: Minimum insertion length of 2-1/2 inches, stainless steel well.

f. Room Sensors: Match room thermostats cover construction, locking cover; element terminated on clamp type connectors or plug-in strip; push button for over-ride of unoccupied functions, where indicated; plug-in communications jack.

g. Outside-Air Sensors: Watertight inlet fitting, shielded from direct sunlight.

3. Temperature Transmitters: Utilize RTD elements, and shall output a 4-20 mA or 0-10 VDC linear signal over the specified range. Zero point and span shall be adjustable over a minimum of 75 percent of range.
   a. Accuracy: Plus or minus 0.5 percent of span
   b. Linearity: Plus or minus 0.2 percent of span
   c. Isolation: Input to output, 600 VDC or A.C. peak
   d. Housings: Mounted on supply ducts or in non-hazardous spaces shall be NEMA 1:
      1) In outdoor air, on outdoor air plenums or intake ducts, or in spaces whose ambient temperature is below 55 deg F, shall be gasketed die-cast aluminum, NEMA 3R minimum.
   e. Range: Suit the application, and shall be 120 deg F for ducts, 150 deg F for outdoor air sensing, 100 deg F for chilled water and 200 deg F for hot water.
   f. Transmitters in outdoor air shall be designed to withstand outdoor conditions and be provided with approved sun shields.
   g. Transmitters shall be the DDC system manufacturer’s product compatible with the building automation system.

4. Humidity Sensors and Transmitters: Bulk polymer sensor element; manufactured by Rotronic Instrument Corporation or Vaisala, Inc.
   a. Accuracy: Plus or minus 2 percent for the 0 to 90 percent range and plus or minus 3 percent for the 90 to 100 percent range.
   b. Wire: Twisted, shielded-pair cable.
   c. Time Response: 90 percent in 15 seconds.
   d. Stability: Plus or minus 1 percent RH per year.
   e. Sensor Temperature Dependence: Plus or minus 0.8 percent additional error at maximum and minimum operating temperatures.
   f. Calibration: Transmitter shall be capable of relative humidity calibration without disturbing operation, using a single point electronic field calibrator.
   g. At contractor’s option, humidity sensors may be combination type and include space, duct, or outdoor air temperature sensing. The combination sensor to meet the above requirements (including approved manufacturers) while the temperature sensor shall meet the following:
      1) Temperature sensor shall have the following characteristics:
         a) Type: Platinum 1000-ohm RTD.
         b) Accuracy: Plus or minus 0.4 deg F at 68 deg F.
         c) Temperature coefficient: Plus or minus 0.009 deg F per deg F.
         d) Range: Suitable for application.
   h. Output Current: Linear output signal of 4-20mA DC into 500 ohms (minimum) at 24V DC supply.
   i. Room Sensors: Locking cover matching room thermostats cover construction, span of 20 to 90 percent relative humidity, transmitter temperature range of 23 to 131 deg F.

j. Duct Sensors: With mounting plate, range of 0 to 100 percent relative humidity; element length to match specified requirements; NEMA 4 enclosure for electronics; transmitter temperature range of minus 40 to plus 176 deg F.
k. Outside-Air Sensors: Range of 0 to 100 percent relative humidity; transmitter temperature range of minus 40 to plus 131 deg F; NEMA 4 enclosure for electronics; transmitter probe shall be mounted in a naturally aspirated solar radiation and precipitation shield.

5. Differential Pressure Transmitters - Water: Direct acting for liquid service; diaphragm operated; 5 valve manifold; range suitable for system, minimum 50 percent greater than nominal system working pressure; proportional output 4 to 20 mA; manufactured by Setra or approved equal.
   a. Accuracy: Plus or minus 0.2 percent of calibrated span
   b. Hysteresis: 0.05 percent of calibrated span
   c. Linearity: Plus or minus 0.1 percent of calibrated span
   d. Damping: Adjustable time constant
   e. Calibration: Zero point and span adjustable to within 0.5 percent of full span
   f. Wetted Parts: 316 stainless steel, monel or nickel-chrome carbon steel or aluminum, NEMA 4
   g. Zero Suppression: 100 percent of span
   h. Over-range Limit: 200 percent of transmitter range.
   i. Pipe Connection: Three connections at 120 degree intervals around circumference of pipe, manifolded for improved average sensing accuracy.

B. Carbon-Dioxide Sensor and Transmitter: Single detectors, using gold-plated non-dispersive infrared optical sensors with automatic baseline correction for self-calibration, suitable over a temperature range of 35 to 120 deg F and humidity range of 0 to 950 percent relative humidity non-condensing, with continuous or averaged reading, 4 to 20 mA output.
   1. Measurement range, linear: 0 to 2000 ppm.
   2. Accuracy: Plus or minus 1 percent measurement range plus 3 percent of reading.
   3. Wire: Twisted, shielded-pair cable.
   4. Normal linear output: 4-20 mA.
   5. Room Sensors: Locking cover matching room thermostats cover construction.
   6. Duct Sensors: With mounting plate, sensor shall be in duct, transmitter shall not require a separate aspiration assembly.
   7. Wireless sensor receivers:
   8. Outside-Air Sensors: NEMA 4 enclosure, naturally aspirated solar radiation and precipitation shield.
   9. Factory written recommendation for calibration shall be never (self-calibrating).
   10. Manufacturers: Air Test Technologies, Inc. or approved equal.
   11. At Contractor’s option carbon dioxide sensors may be the DDC system manufacturer’s product, and may be integral with the space temperature sensor housing, provided sensor meets the performance above for the independent units.

C. 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. Provide where Division 26 is not providing for lights.

D. Status Inputs for Electric Motors: Current-sensing relay with current transformers; solid state type, adjustable and set to 175 percent of rated motor current, with the following characteristics:
   1. Rating: 0 to 135 amps.
   2. Sensor Voltage: Induced from monitored conductor
   3. Supply Current: Induced from monitored conductor

4. Isolation: Minimum 600 VAC rms
5. Trip Set Point: Adjustable to ±7% of range
6. Zero Adjustment: None
7. Sealing: NEMA 12
8. Temperature Range: 15°C to 85°C
9. External Current Transformers: For loads exceeding 135 amps.

E. Electronic Valve/Damper Position Indication: Visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.

F. Water-Flow Switches: Pressure-flow switches of bellows-actuated mercury or snap-acting type, SPDT, minimum 7 amp rating resistive at 120 vAC, with appropriate scale range and differential adjustment, with stainless-steel paddle and NEMA 1 enclosure. For ground loop water applications, provide vaporproof type.

G. Differential Pressure Switches 0" to 10" W.C. - Air: Diaphragm actuated SPDT; minimum rating 5 amps resistive 120 VAC; aluminum or steel NEMA 3R housing; 0.30 inches wg deadband; fully adjustable setpoint over switch range; manual reset snap switch;
   1. Diaphragm Material: Silicone rubber of Buna-N.
   2. Auxiliary Contacts: To allow duct static pressure switch to be connected to both the DDC system and starter circuit.
   3. Manufacturers: Penn or Dwyer Mercoid.

H. Differential Pressure Switches - Water: SPDT: Minimum 4 amp inductive rating at 250 VAC; diaphragm or bourdon tube actuated, with adjustable setpoint and maximum switch deadband of 1.5 psi; 150 psi differential working pressure; NEMA 4 housing; manufactured by Penn or Dwyer Mercoid.

I. Limit Switches: Minimum rating of 10 amps resistive at 120 VAC; two pole single or double throw; NEMA 3R enclosure; aluminum or stainless steel switch actuation rod; manufactured by Honeywell Micro-Switch, Cutler Hammer, or Allen Bradley.

J. Damper Blade End Switches: Momentary-type for monitoring the motion of the damper at a prescribed arc of rotation; hermetically sealed mercury type; one or two SPDT contact arrangement as required with current carrying characteristics of 4 amps at 120V AC; manufactured by Dwyer Mercoid or approved equal.

K. Float Switch: SPDT contacts, UL recognized, CSA certified, L-bracket mount, equal to Kele model JMP Series.

L. Water Meters:
   1. Provide an Inline Electromagnetic Flow Meter complete with remote backlit graphic display and keypad and capable of providing the following information:
      a. Total Volume – In Gallons [Gal], Liters [Liter] and Hundred Cubic Feet [CCF].
      b. Volume Flow Rate – In both Gallons per Minute [GPM]; Gallons per hour [GPH], Liters per Second [L/SEC], Liters per Minute [L/Min], Liters per Hour [L/HR], etc.
      c. All readings must have a minimum accuracy of +/- 0.4%.
      d. Minimum of two (2) programmable digital/pulse outputs that are configurable for frequency, pulse or directional flow).
      e. Minimum of one (1) isolated 4-20mA analog output for flow rate.

f. All values must be capable of being communicated and remotely read via Modbus RTU over RS 485. Provide Moore Industries HCS Hart to Modbus converter as required for communication.
g. Display shall be installed at 5'-0" above finished floor.

2. Accuracy - Accurate to within ±0.5% of rate at the calibrated typical flow rate and within ±2% of rate over an extended 50:1 turndown range (0.4 - 20 ft/s).
3. Bidirectional Flow - Meter must be capable of bi-directional flow measurement.
4. Connection Type – Provide ANSI Class 150 Flanges. Wafers are not approved. Provide all necessary mating flanges and any required reducer/expanders.
5. The flow tube shall be epoxy coated steel; the sensing electrodes shall be 316SS; the liner shall be polypropylene for chilled water service, PFTE for hot water service (302 F maximum), and suitable for service conditions. For domestic water service, provide NSF 61 certified meters for use in potable water systems.
6. Each flow meter shall be factory programmed for its specific application, and shall be re-programmable using the integral keypad on the converter (no special interface device or computer required).
7. Up-/Downstream Pipe Diameters – Regardless of piping configuration/meters' relative location in piping system, provide a minimum of four (4) straight pipe runs on both the upstream and downstream piping sections of the meter.
8. Control Power – Contract electrical contractor to provide 120VDC electrical branch circuit to Flow meter via #12 awg stranded copper and ¾" EMT conduit with compression fittings. Flow meter to include internal 120VDC output capability.
9. Manufacturer's Commissioning – Commission the flow meter manufacturer to confirm meter installation is satisfactory and/or to make any adjustments to the meter operating parameters to offset the existing field conditions and to coordinate with the building automation vendor for performing meter startup, programming and integration with the building automation system. The building automation system vendor or other contractor is not an acceptable substitute.
10. Approved Manufacturers:
    a. Onicon F-3100 Series with MODBUS RTU interface.
    b. Rosemount 8700
    c. Yokogawa AFX

2.5 THERMOSTATS

A. Low-Voltage, On-Off Thermostats: NEMA DC 3, 24-V, bimetal-operated, mercury-switch type, with adjustable or fixed anticipation heater.

B. Line-Voltage, On-Off Thermostats: Bimetal-actuated, open contact or bellows-actuated, enclosed, snap-switch type, or equivalent solid-state type, with heat anticipator, integral manual on-off-auto selector switch.
1. Equip thermostats, which control electric heating loads directly, with off position on dial wired to break ungrounded conductors.
2. Dead Band: Maximum 2 deg F.

C. 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, 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.

D. Room Thermostat Cover Construction: Manufacturer's standard locking covers.
1. Set-Point Adjustment: Exposed in offices, concealed elsewhere; adjustment via slide bar.
2. Set-Point Indication: Exposed.
3. Thermometer: None.
4. Material: Plastic.
5. Orientation: Vertical or horizontal.

E. Room thermostat accessories include the following:
1. Insulating Bases: For thermostats located on exterior walls.
2. Thermostat Guards: Locking, solid metal, ventilated.
3. Adjusting Key: As required for calibration and cover screws.

F. Immersion Thermostat: Remote-bulb or bimetal rod-and-tube type, proportioning action with adjustable throttling range and adjustable set point.

G. Heating/Cooling Valve-Top Thermostats: Proportional acting for proportional flow, 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.

2.6 ACTUATORS

A. Sizing:
1. Dampers: Size for required running torque and 120 percent of the required full load opening torque.

B. Electronic Damper Actuators: Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.
1. Coupling: V-bolt and V-shaped, toothed cradle.
2. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
3. Fail-Safe Operation: Mechanical, spring-return mechanism. Provide external, manual gear release on non-spring-return actuators.
4. Power Requirements (Two-Position Spring Return): 24-V ac.
5. Power Requirements (Modulating): Maximum 10 VA at 24-V ac or 8 W at 24-V dc.
6. Proportional Signal: 2- to 10-V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal.
7. Temperature Rating: Minus 22 to plus 122 deg F.
8. Temperature Rating (Smoke Dampers): Minus 22 to plus 250 deg F.
9. Run Time: 30 seconds.
10. Electrical Connection: Provide conduit fitting with minimum 3 feet of pre-wired electrical cable.

2.7 DAMPERS

A. General: Damper construction specifications are minimum required. Damper static pressure ratings shall meet or exceed the rating of the ductwork or system in which they are installed.
   1. Unless otherwise specified, dampers for modulating service shall be opposed blade design and dampers for two position service shall be parallel blade design.
   2. Coordinate dampers specified with equipment in other Division 23 Sections, including the following:
      a. Section 23 74 13 “Modular Air-Handling Units.”
      b. Section 23 74 12 “Custom Air-Handling Units.”
      c. Section 23 33 00 “Air Duct Accessories.”
      d. Section 23 34 23 “HVAC Power Ventilators.”
   3. Smoke and combination smoke and fire dampers are specified in Section 23 33 00 “Air Duct Accessories.”

B. Control Dampers: AMCA-rated, opposed-blade design; 0.11-inch minimum, galvanized-steel frames with holes for external duct mounting; damper blades shall not be less than 0.06-inch galvanized steel with maximum blade width of 6 inches.
   1. Blades shall be secured to 1/2-inch- diameter, zinc-plated axles using zinc-plated hardware, with nylon 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. Maximum 48 inch blade length.
   2. Operating Temperature Range: From minus 10 to plus 150 deg F.
   3. Seals: Inflatable type blade edging, or replaceable rubber type, rated for leakage at less than 10 cfm per sq. ft. of damper area, at differential pressure of 4 inches wg when damper is being held by torque of 50 in. x lbf; when tested according to AMCA 500D.
   4. Damper assembly shall have no sections longer than 48 inches wide or 48 inches high. Where greater length or height is required the assembly shall be made from a combination of sections.
   5. Connection rods transmitting motion from damper motors to damper, shall be sized to withstand as load equal to at least twice the minimum damper operating force without deflection. Lengths shall be adjustable. Links shall be cadmium plated steel, brass or bronze.
   6. Manufacturers:
      a. Rectangular: Ruskin CD-36, American Warming VC-20/21, or Johnson Controls D-1300.
      b. Round: McGill Airflow Corporation Type 1 or Type 2 high pressure type.

2.8 MISCELLANEOUS DEVICES

A. Provide necessary relays, accumulators, valves, positioners, switches, transformers, etc. to make a complete and operable system.

B. Time Delay Relays: Delay-on-energize or delay-on-release as shown; select range for the application as specified and shown.
   1. DPDT timed contacts with minimum continuous rating of 10 amps resistive at 120 VAC.
   2. Coils rated for continuous duty at plus or minus 10 percent of nominal coil pilot voltage.
   3. Manufacturers: Potter Brumfield, Magnecraft, Agastat, or Paragon.

C. Control Relays: Normally open (NO) or normally closed (NC) contacts and number of poles required to perform the indicated functions.

1. Contacts rated for no less than 110 percent of switched load, or a minimum continuous rating of 10 amps at 120 VAC.
2. Coils rated for continuous duty at 100 percent plus or minus 10 percent of the nominal coil pilot voltage.
3. Relays mounted within panels may be plastic encapsulated socket mounted type, or modular design with multiple convertible contacts, as required.
4. Relays located outside of panels shall be housed in enclosures rated for the intended location.
5. Manufacturers: Johnson Controls or approved equal.

D. Cable-Type, Leak-Detection System:
   1. Manufacturers: Subject to compliance with requirements, provide products by the following:
      a. KELE.
      b. RLE Tech.
      c. Veris.
      d. W. E. Anderson; Dwyer Instruments, Inc.
   2. Control Module Features:
      a. Power and alarm LEDs.
      b. Alarm test switch.
      c. Continuous tape integrity self check.
   3. Performance:
      a. Service: Water, or other conductive liquid.
      b. Switch Type: DPDT.
      c. Electric Connection: Screw terminals.
      d. Conduit Connection: 0.5 inch.
   4. Construction:
      a. Control Module Enclosure: Extruded aluminum.
      b. Tape: Hydrophobic with connector on each end.
      c. Tape Length: 60 inches, 10 feet, or 15 feet as required for application. Field extendable.
   5. Field Power: 24-V ac or 24- to 30-V dc

2.9 THERMOMETERS

A. Provide direct-reading duct thermometers that are readable by a person standing on the floor in the following locations:
   1. At air handling units, where indicated on the ATC schematics.

B. Thermometers are specified in Section 23 05 19 “Meters and Gages for Mechanical Piping.”

2.10 ELECTRICAL WIRING

A. General Wiring Requirements:
   1. Wiring shall comply with the requirements of local and national electric codes and Division 26 specification requirements, and the requirements herein specified.
   2. Electric wiring and wiring connections required for the installation of the ATC, as herein specified, shall be provided by this specification unless specifically shown or called for in other specifications.
      a. Control wiring shall include connections to control devices, interlock wiring, control relays, and minor power wiring to auxiliary components for major pieces of

apparatus. Minor power wiring, 120 volts and below, shall include requirements for such equipment as damper motors, solenoid valves, and interconnecting wiring on apparatus that has not been factory installed. In general, control wiring that is not factory installed or provided under other Divisions shall be provided.

b. Power wiring, for the purpose of this specification, shall be defined as follows: Wiring from the power source, i.e., panelboard, or motor control center, etc., to the disconnect switch or disconnect switch and starter including wiring from these switches to the apparatus.

3. Power for control devices, whether or not interlocked with motor operation, shall be obtained from a separate 120 VAC source at the ATC panel or where directed. The Contractor shall be permitted to wire one control relay or one solenoid valve with maximum power draw of 50 VA, to derive pilot power directly from the motor starter control circuit. Devices are to be located remote and external from motor starter. Device wiring is to terminate on terminal blocks provided in motor starter compartments. No splices are permitted. Provide power wiring from the source to field mounted control devices and panels.
4. Coordinate with the work of others. The plans are diagrammatic only and are to be utilized as reference. Interconnection and coordination requirements necessary for a totally operational control system are the requirement of this Section.
5. Operate electric and electronic mechanical controls at maximum 120 volts or less. Provide voltage transformers and isolated relays where indicated or required for control systems that operate at voltage other than 120V ac.
6. Transformers other than those used in bridge circuits shall have primaries wound for the available current and secondaries wound for the correct control circuit voltage. Size to have capacity capable to operate simultaneously components served plus 25 percent overload for one hour. Enclose transformer in vented steel cabinet with conduit connections and provide disconnect switch on the primary side and fused cut-out on the secondary side.
7. Provide contactors, relays, and authority devices for control of single-phase equipment.
8. Duct smoke detectors are specified in Section 28 31 00 “Fire Detection and Alarm Systems.” Provide contactors for connection to both the DDC system and fan starter circuits.

B. Control Transmission Cabling:
1. Twisted, shielded-pair cable, rated for use in return air plenums.

2.11 SOURCE QUALITY CONTROL

A. Perform manufacturer's standard shop tests for each component.

PART 3 - EXECUTION

3.1 ACTUATOR APPLICATION SCHEDULE

A. Generally, provide electric/electronic actuators.

3.2 EXAMINATION

A. Verify that conditioned power supply is available to control units and operator workstation.

B. Verify that duct-, pipe-, and equipment-mounted devices and wiring are installed before proceeding with installation.

C. Examine areas and conditions under which control systems are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected.

3.3 INSTALLATION

A. Install systems and materials in accordance with manufacturer's instructions and roughing-in drawings, and details on drawings.

B. Mount controllers at convenient locations and heights.

C. Install equipment level and plumb.

D. Install software in control units and operator workstation. Implement all features of programs to specified requirements and as appropriate to sequence of operation.

E. Connect and configure equipment and software to achieve sequence of operation specified.

F. Verify location of thermostats, humidistats, and other exposed control sensors with plans, room details, and Architect before installation. Generally, locate all 48 inches above the floor; align centerline with centerline of adjacent light switches.
   1. Install averaging elements in ducts and plenums in crossing or zigzag pattern, supported by mechanical clips.
   2. Thermostats and humidistats located on exterior walls shall be mounted on back-insulated blocks.

G. Install guards on room sensors in the following locations:
   1. Stair wells.

H. Install automatic dampers according to Section 23 33 00 "Air Duct Accessories."

I. Install damper motors on outside of duct in warm areas, not in locations exposed to outdoor temperatures.

J. Install labels and nameplates to identify control components according to Section 23 05 53 “Identification for Mechanical."

K. Install hydronic instrument wells, valves, flow switches, flow meters, and other accessories according to Section 23 21 13 "Hydronic Piping."

L. Install duct volume-control dampers according to Division 23 Sections specifying air ducts.

M. Provide weathershield/enclosure to protect actuators and linkages from outside conditions of snow and ice build-up.

N. Provide NEMA 4 enclosures for electric or electronic devices mounted in outdoor locations.

O. Mounting of Panels: Control panels shall be installed so that they are stable and fully supported throughout the entire panel, minimum one inch from the wall. Panels mounted on air system housings or ducts are not acceptable. Ensure that panels are free from obstructions to allow for ease of operation and maintenance.

P. Load and debug software required for an operational DDC System, including data base, operational parameters, and system control and application programs.

Q. Install flow meters in accordance with manufacturers written recommendations for straight piping lengths upstream and downstream of meter.

3.4 ELECTRICAL WIRING AND CONNECTION INSTALLATION

A. Install raceways, boxes, and cabinets according to Section 26 05 33 "Raceways and Boxes for Electrical Systems."
   1. Minimum conduit size: 3/4 inch.

B. Install building wire and cable according to Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

C. Install control transmission cable according to industry standards and as follows:
   1. Mechanical rooms, areas where other conduit and piping are exposed, and in masonry walls: install cable in raceway.
   2. Outdoors: Install cable in Schedule 40 PVC conduit. Upon entering and leaving a building, each conductor, including ground shield, shall terminate on a surge protector designed to interrupt the circuit and shunt transient voltage to ground.
   3. Within drywall walls and above ceilings:
      a. Cable may be run without conduit protection. Support control transmission cable from structure with tie wraps. It shall be the responsibility of the Contractor to ensure the integrity and proper shielding and grounding of control cable.
      b. Cable may be run in telecommunications cable tray.
   4. Install below grade and outdoor cable in Schedule 40 PVC conduit. Upon entering and leaving a building, each conductor, including ground shield, shall terminate on a surge protector designed to interrupt the circuit and shunt transient voltage to ground.
   5. Bundle and harness multiconductor instrument cable in place of single cables where several cables follow a common path.
   6. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.
   7. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.
   8. No splices or kinks shall be permitted in control transmission cable. Terminations shall be on panel-mounted terminal strips.
   9. Grounding shall be in accordance with ANSI C2. Ground wire shall be copper. Control cable, including communication links and sensor wiring, shall be grounded at only one point for the entire system. Sensor wiring ground wires shall be terminated at the DCP and connected to the communication link ground wire. Communication link ground wires shall be terminated and grounded at the CPU.
   10. Power wiring shall not be routed through the same raceway as control transmission cable.
   11. At Contractor’s option, cable may be run in telecommunications cable tray.

D. Low voltage (50 volt or less) remote control and signal wiring may be run in multi-conductors cable with PVC insulation, mylar binder and PVC jacket. Use "plenum approved" cable in return air plenums. Entire installation shall be in accordance with Article 725 NEC, and shall meet additional requirements noted. Cables carrying AC circuits sensitive to external field shall be shielded. Exception: Control wiring shall be in conduit in mechanical and electrical equipment rooms, in shafts and where exposed.

E. Connect hand-off-auto selector switches to maintain automatic interlock controls when switch is in hand position.

F. Control power may be derived from line side of a starter provided circuits are fused and controls so energized are associated only with this starter and motor.

G. Control transformer furnished as an integral part of a starter shall not be used as a power source for additional control.

H. Starter disconnect or separate switch immediately adjacent to starter shall disconnect power from line voltage or 120 volt control wiring entering starter.

I. Controllers and Operators: Controls shall be designed to function properly with a power source voltage variation of plus or minus 10 percent.

3.5 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
   1. Install piping adjacent to machine to allow service and maintenance.

B. Pressure sensors installed on liquid lines shall have siphons. Pressure sensors shall have valves for isolation and venting, and taps for calibration. Pressure sensors shall be verified by calibration. Differential-pressure sensors shall have three-way manifold valves.

C. Pressure switches installed on liquid lines shall have siphons. Pressure switches shall have valves for isolation and venting, and taps for calibration. Pressure switches shall be adjusted to the proper setpoint, and shall be verified by calibration. Pressure switches shall be mounted higher than the process connection. Differential-pressure switches shall have three-way manifold valves. Switch contact ratings and duty shall be selected for the expected load.

D. Provide necessary pressure fittings for installation of work. Size (for the specific range) and adjust each differential-pressure switch used for fan and pump status to ensure reliable monitoring and eliminate false status feedback.

E. Ground equipment.

F. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.6 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including piping and electrical connections. Report results in writing.

1. Operational Test: Prior to testing, confirm system graphics are complete, points have been mapped into the graphics, and the graphics have been reviewed for content and completeness by the owner, architect, and construction manager. After electrical circuitry has been energized, start units to confirm proper unit operation. Remove malfunctioning units, replace with new units, and retest.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment, and retest.
3. Calibration test electronic controllers by disconnecting input sensors and stimulating operation with compatible signal generator.
4. Instruments and sensors shall be field calibrated by comparison to known device, which is traceable to National Institute of Standards and Testing and has a certification that is less than a year old. Proof of certification shall be available on site for review upon request. The standards and accuracy requirements for calibration equipment shall be equal to or higher than the accuracy specified for the device being checked. Contractor shall document the field calibration and submit the documentation.
5. Coordinate calibration with space temperature measurements specified in Section 23 05 93 “Testing, Adjusting, and Balancing for HVAC.”

B. Engage a factory-authorized service representative to perform startup service.
   1. Flow Meters – Engage the flow meter manufacturer to confirm meter installation is satisfactory and to make any adjustments to the meter operating parameters to offset the existing field conditions and to coordinate with the building automation vendor for performing meter startup, programming and integration with the building automation system.

C. ATC contractor shall include 8 hours and a meeting with the Owner to prioritize alarm points and establish actions such as whom to email or call, type of alarm, etc.

D. Replace damaged or malfunctioning controls and equipment.
   1. Start, test, and adjust control systems.
   2. Demonstrate compliance with requirements, including calibration and testing, and control sequences.
   3. Adjust, calibrate, and fine tune circuits and equipment to achieve sequence of operation specified.

E. Place Building Automation System (BAS) in the required modes of operation as requested by the Testing and Balancing Contractor (TAB). Provide programming changes and reporting of data from the BAS needed to achieve proper performance.

F. Re-check fan static pressure control setpoints to ensure that the static pressure setpoints are the lowest value which enables terminal units to deliver design maximum flow plus or minus 10 percent with the variable frequency controller at maximum speed. The TAB Contractor shall make any fan adjustments needed. Adjust setpoint as requested by the TAB Contractor.

G. Re-check pump differential pressure control setpoints to ensure that the differential pressure setpoints are the lowest value which enables coil ATC valves to deliver design maximum flows plus or minus 10 percent. Adjust setpoint as requested by the TAB Contractor.

H. Verify DDC as follows:
   1. Verify software including automatic restart, control sequences, scheduling, reset controls, and occupied/unoccupied cycles.

2. Verify operation of operator workstation.
3. Verify local control units including self-diagnostics.

I. Initial Demonstration Test: Upon the completion of work and functional performance acceptance period, tests, and specific function demonstrations, and at a time agreed upon, operate the systems, in parts, for sufficient length of time but not less than 30 days to determine whether the systems as a whole are functioning properly.
   1. Provide log identifying failures that occur. Indicate point name and number, time and date of failure, and time and date of return to service.

J. Most of the mechanical systems are included in the Commissioning Program. Pretest the functional operation of the system and document tests with the construction manager, such that the first time through the system operation is not during the commissioning agent's Functional Test. Refer to the following specification sections for requirements associated with Commissioning:
   1. Section 01 91 13 "General Commissioning Requirements".

3.7 DEMONSTRATION AND TRAINING

A. Submit an instrumentation and controls system training plan with agenda for owner review. Provide a minimum 8-hours of owner demonstration. Refer to Section 01 73 50 "Demonstration and Training" for training requirements for Owner's maintenance personnel and building occupants.

3.8 ON-SITE ASSISTANCE

A. Occupancy Adjustments: Within one year of date of Substantial Completion, provide up to three 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.

END OF SECTION

SECTION 230901 - AIR MEASURING SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following air measuring systems for mechanical systems:
   1. Air-flow measuring systems in ductwork.
   2. Air-flow measuring systems in plenums.
   3. Static-pressure measuring systems in ductwork.

B. Related Sections include the following:
   1. Section 233300 "Air Duct Accessories" for general installation requirements.
   2. Section 230900 "Instrumentation and Control for HVAC" for wiring.
   3. Most of the mechanical systems are included in the Commissioning Program. Refer to the following specification sections for requirements associated with Commissioning:
      a. Section 019113 “General Commissioning Requirements.”

1.3 DEFINITIONS

A. Combined Tested Accuracy: The combined percentage accuracy of the air-flow or static-pressure measuring system (sensor and transmitter) when installed in accordance with manufacturer’s written recommendations.

B. DDC: Direct digital controls.

C. Installed Accuracy: The combined percentage accuracy of the air-flow or static-pressure measuring system (sensor and transmitter) in the location indicated on the drawings.

D. Measuring System: Combination of sensor(s), transmitter(s), and monitor(s).

E. Tested Accuracy: The percentage accuracy of sensor or transmitter when installed in accordance with manufacturer’s written recommendations.

1.4 SUBMITTALS

A. Product Data: Include manufacturer's technical literature for each air measuring system. Indicate dimensions, capacities, performance characteristics, electrical characteristics, materials of construction, installation details, mounting type, air pressure drop, and installation and startup instructions for each type of product indicated.
   1. Each air measuring device labeled with setting or adjustable range of control, minimum placement requirements, sensor density, sensor distribution, and installed accuracy.

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. Installation Drawings: Prepared by manufacturer for each system indicating location and mounting of each component, dimensions relative to plenum walls, baffles, etc.
   2. Wiring Diagrams: Power, signal, and control wiring. Differentiate between manufacturer-installed and field-installed wiring.
   3. Details of panel faces, including controls, instruments, and labeling.
   4. Schedule of air-flow measuring devices indicating airflow, pressure drop, and compliance with specified installed accuracy at minimum and maximum air-flow rates for each location.

C. Maintenance Data: For systems to include in maintenance manuals specified in Division 01. Include the following:
   1. Maintenance instructions and lists of spare parts for each type of air measuring device.
   2. Interconnection wiring diagrams with identified and numbered system components and devices.
   3. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
   4. Calibration records and list of set points.

D. Qualification Data: For firms and persons specified in "Quality Assurance" Article.

E. Project Record Documents: Record actual locations of air measuring device components.

F. Source quality control test reports.

1.5 QUALITY ASSURANCE

A. Source Limitations:

B. If sub-paragraph is retained below and fan inlet probes are specified, only thermal dispersion systems will satisfy this requirement.
   1. Air-Flow Measuring Devices: Obtain air-flow measuring devices through one source from a single manufacturer with resources to provide products complying with requirements indicated without delaying the Work.
   2. Static-Pressure Measuring Devices: Obtain static-pressure measuring devices through one source from a single manufacturer with resources to provide products complying with requirements indicated without delaying the Work.

C. Installer Qualifications: An experienced installer who is an authorized representative of the air measuring system manufacturer for both installation and maintenance of units required for this Project.

D. Manufacturer Qualifications: A firm experienced in manufacturing air measuring systems similar to those indicated for this Project and with a record of successful in-service performance for a minimum of 10 years.

E. 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.

F. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilation Systems."

1.6 DELIVERY, STORAGE, AND HANDLING

A. Delivery: Deliver materials to site in manufacturer's original, unopened containers and packaging, with labels clearly indicating manufacturer and material.

B. Storage: Store materials in a clean and dry area indoors, protected from weather and damage, and in accordance with manufacturer's instructions.

C. Handling: Handle and lift air measuring devices in accordance with manufacturer's instructions. Protect materials and finishes during handling and installation to prevent damage.

D. Delete if not applicable to project.

E. Factory-Mounted Components: Where devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to unit manufacturer.

1.7 COORDINATION

A. Coordinate location of air measuring system devices with plans, ductwork, and equipment before installation.

B. Coordinate supply of conditioned electrical circuits for air measuring devices.

C. Coordinate shipment of fan inlet air measuring devices to custom air handling unit manufacturer for factory mounting and testing of fans.

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

2.2 INSTALLED ACCURACY

A. Provide devices with specified installed accuracies throughout the measurement range (minimum to maximum) and with inlet and outlet conditions indicated on the drawings.

B. Air-Flow Measuring Systems Installed Accuracy: Maximum plus or minus 5 percent.

C. Static-Pressure Measuring Systems Installed Accuracy: Maximum plus or minus 5 percent.

D. Thermal dispersion theoretical minimum velocity is 50 FPM, but for outside air ducts a minimum of 200 FPM is recommended to avoid “false” wind readings. In addition, follow manufacturer guidelines for placement (distances from louvers, etc.).

2.3 THERMAL DISPERSION AIR-FLOW MEASURING DEVICES

A. Manufacturers: Ebtron, Inc. Gold Series.

B. Sensor Construction:
   1. Duct, fan inlet, and plenum mounted sensors: Anodized aluminum alloy tube with stainless steel mounting brackets. Fan inlet sensors shall be field adjustable to fit the fan inlet.
   2. Delete paragraph below if not applicable to project.

C. Each measuring system shall consist of one or more multi-point measuring probes and a single microprocessor-based transmitter.

D. Transmitters shall have an LCD display capable of displaying average air-flow and temperature and air-flow and temperature of each sensor. Air-flow shall be field configurable to be displayed as a velocity or volumetric rate. Each transmitter shall operate on 24 VAC.

E. Each sensing point shall independently determine the air-flow rate and temperature, which shall be equally weighted and averaged by the transmitter prior to output.

F. A single manufacturer shall provide both the air-flow/temperature measuring probe(s) and transmitter at a given measurement location. Probes and transmitters shall not require field matching for proper operation.

G. Operating Air-flow Range: 50-5,000 FPM unless otherwise indicated on the plans.

H. Operating Temperature and Humidity Range for Measuring Probes: -20 deg. F to 140 deg. F and 0-99% RH (non-condensing).

I. Operating Temperature Range for the Transmitter: -20 deg. F to 120 deg. F. The transmitter shall be protected from weather and water; provide NEMA 3R enclosure with heater and cooling fans for transmitters mounted outside or within air handlers.

J. Air-flow Sensor Accuracy: Plus or minus 2 percent of reading over the entire operating air-flow range. Wind tunnel calibrate or verify against standards that are traceable to NIST.
   1. Devices whose accuracy is the combined accuracy of the transmitter and sensor probes must demonstrate that the combined total accuracy meets the performance requirements of this specification throughout the measurement range.

K. Temperature Sensor Accuracy: Plus or minus 0.15 deg. F over the entire operating temperature range. Calibrate or verify against standards that are traceable to NIST.

L. Minimum Sensor Quantity for Each Location:
   1. Ducts and plenums:

Area (sq.ft.)	Sensors
<=1	2
>1 to <4	4
4 to <8	6
8 to <12	8
12 to <16	12
>=16	16

2. Delete paragraph below if not applicable to project.

M. The transmitter shall be capable of communicating with the building DDC system using the following interface options:
   1. Linear analog output signal: Field selectable, fuse protected and isolated, 0-10VDC and 4-20mA (4-wire).
   2. RS-485: Field selectable ModBus-RTU and Johnson Controls N2 Bus.
   3. 10 Base-T Ethernet: Field selectable ModBus TCP and TCP/IP.
   4. LonWorks Free Topology.

N. Minimum Outputs: Airflow and temperature.

O. Airflow measuring system shall be UL listed as an entire assembly.

P. The manufacturer's authorized representative shall review and approve placement of each sensor and transmitter and operating air-flow rates for each measurement location indicated on the plans. A written report shall be submitted to the Architect if any measurement locations do not meet the manufacturer's placement requirements.

Q. Differential pressure probe minimum velocity is 150 FPM. A special version of this product is available with a full range of 150-2000 FPM. A duct station version of this product (with expanded metal plate) is also available.

2.4 PITOT TUBE STATIC PRESSURE MEASURING SYSTEM

A. Probes:
   1. Manufacturer: Air Monitor Corporation.
   2. Style: Duct static traverse probes capable of continuously monitoring the duct or system static pressure it serves.
   3. Construction: Each duct static traverse probe shall contain multiple static pressure sensors located along the exterior surface of the cylindrical probe. Sensors shall not protrude beyond the surface of the probe. The duct static traverse probes shall be of extruded aluminum construction and be complete with threaded end support rod, sealing washer and nut, and mounting plate with gasket and static pressure signal fitting.
   4. Performance: The static traverse probes shall be capable of producing a steady, non-pulsating signal of standard static pressure, without need for correction factors, with an instrument accuracy of 2 percent.
   5. Specified transmitter (Veltron DPT 2500) has manual zero capability, which is recommended when static pressure is utilized to control fan speed. A display is available as an option, but is not specified here.

B. Transmitter:
   1. Manufacturer: Veris PX Series.
   2. Style: Electronic transmitter with LCD display, 3-way manual zeroing valve, user selectable square root function; designed for exposed mounting in protected (building) areas to measure static pressure or differential pressure, and output a 4-20 mA output linear to static pressure, airflow velocity, or volume.
   3. Performance: The transmitter shall conform to the following:
      a. Accuracy: Plus or minus 0.5 percent of Natural Span, including non-linearity, hysteresis, and non-repeatability.
      b. Spans: (7) Natural, from 0-0.10 inches wg to 0-10.0 inches wg.; (7) Bi-Polar.

c. Temperature Effect: Zero: Plus or minus 0.025 percent of Full Scale/deg F.
d. Span: Plus or minus 0.025 percent of Full Scale/deg. F.
e. Power Supply: 14-40 VDC for all models, reverse polarity short-circuit proof.
f. Analog Outputs: 4-20 mADC, 2-wire configuration.
g. Temperature Limits: 40 to 120 deg. F Operating.
h. Maximum Overpressurization: 25 psig.

4. Locate in BAS panel, with sensing tubes routed to probes.

2.5 SOURCE QUALITY CONTROL

A. Factory Tests: Factory test and calibrate sensor, transducer, and monitor for proper operation.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Inspect areas to receive air-flow and static-pressure measuring devices. Notify the Architect of conditions that would adversely affect the installation or subsequent utilization of the air-flow or static-pressure measuring devices. Do not proceed with installation until unsatisfactory conditions are corrected.

3.2 AIR-FLOW MEASURING DEVICE APPLICATIONS

A. Install duct- or plenum- mounted air-flow measuring devices not within air handling units utilizing thermal dispersion probes.

3.3 STATIC-PRESSURE MEASURING DEVICE APPLICATIONS

A. Install pitot tube probe static-pressure measuring devices in ductwork.

3.4 INSTALLATIONS

A. Assemble and install connections, tubing, and accessories between sensors, transmitters, and monitors as prescribed by manufacturer's written instructions.

B. Install air measuring systems in accessible positions in duct and air-handling systems.

C. Install air measuring sensors at locations indicated on the drawings, and with at least minimum straight lengths of duct upstream and downstream from element as prescribed by manufacturer's written instructions.

D. Install transmitter and monitor electronics at locations indicated on the drawings and in accordance with manufacturer's installation instructions.

E. Penetrations through the air handler walls, ductwork, or hood shall provide some means to prevent tubing and wiring chafe, and be sealed air- and water-tight.

F. Pitot Tube Devices:

1. Install probes such that pressure connections are at or above the centerline of the probe. Connection tubing attaching to the probes shall be pitched downward so that any

accumulated moisture can drain back towards the probe. Tubing shall be installed so that there are no pockets where moisture might accumulate.

2. Install the transmitter such that it is located at a slightly higher elevation than the highest probe. Transmitter shall be mounted so that the pressure connections are on the bottom of the enclosure. Connecting tubing shall be pitched downward and away from the transmitter so that any accumulated moisture can drain back towards the probe. Tubing shall be installed so that there are no pockets where moisture might accumulate.

3.5 CONNECTIONS

A. Install air measuring devices to allow service and maintenance for air measuring devices, machines, and equipment.

B. Connect thermal dispersion, pitot tube, and pressure differential system elements to transmitters and monitors.

C. Provide electric wiring and connections required for air measuring systems. Provide wiring according to Section 230900 "Instrumentation and Control for HVAC."

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."

3.6 CLEANING

A. After Substantial Completion, clean air measuring systems.

3.7 ADJUSTING

A. Setup and calibrate air-measuring devices according to manufacturer's written instructions, after installation.

3.8 COMMISSIONING

A. Most of the mechanical systems are included in the Commissioning Program. Refer to the following specification sections for requirements associated with Commissioning:

1. Section 019113 “General Commissioning Requirements”.

3.9 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner’s maintenance personnel to adjust, operate, and maintain air-measuring devices. Refer to Section 017350 “Demonstration and Training.”

3.10 WARRANTY SERVICE

A. After Substantial Completion, perform a calibration check (compare transmitter output to traverse) for pitot tube and differential pressure probe transmitters at 6 months, 12 months, 18 months, and 23 months after substantial completion. Refer to Section 230593 “Testing, Adjusting, and Balancing for HVAC". If transmitter is out of calibration, engage a factory-authorized service representative to calibrate transmitter.

B. After Substantial Completion, engage a factory-authorized service representative to calibrate pitot tube static pressure measuring transmitters at 23 months after substantial completion.

C. Clean air measuring system sensing devices and air straighteners within the airstream at the following intervals throughout the warranty period:
   1. Supply Air Service: 18 and 23 months.
   2. Return and Outdoor Air Service: 3, 6, 9, 12, 15, 18, 21, and 23 months.

END OF SECTION

SECTION 230993 - SEQUENCE OF OPERATIONS FOR HVAC CONTROLS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes control sequences and input/output summary tables for HVAC systems, subsystems, and equipment.

B. Related Sections include the following:
   1. Section 230900 "Instrumentation And Control For HVAC" for control equipment, control devices, and submittal requirements.

1.3 DEFINITIONS

A. BAS: Building automation system.

B. DDC: Direct-digital controls.

C. FA: Field Adjustable

D. PI: Proportional plus integral control

E. PID: Proportional plus integral plus differential control

F. VAV: Variable air volume

1.4 SEQUENCE OF OPERATIONS:

A. General Requirements:
   1. The sequences listed hereinafter describe the general intent of the automatic temperature control systems. Provide all devices, equipment, and wiring as required to perform the sequences described herein.
   2. See plans for location of all room sensors and thermostats, dampers, valves, and equipment; where such devices are not indicated, however required by the sequences, they shall be provided and located in the field as approved by the Owner.
   3. All belt driven equipment and non-VFC motor driven pumps and fans shall be provided with current transducers for status proof. Calibrate and set up current sensing relays to sense broken couplings and belts.
   4. All temperature, pressure, air flow, water flow and time set points shall be fully adjustable from the Building Automation System (BAS) and the associated system graphic interface.

5. Provide all hardware, software, devices, equipment and wiring as required to interface with the BAS.
6. Refer to input/output summary schedule for additional control items not described in the sequences. The input/output summary schedule list the minimum requirements, provide all required points for complete operation of the system.
7. All two (2) position dampers shall be provided with end switches.
8. The control manufacturer shall prepare and submit for approval a composite control and interlock wiring diagram depicting the control system that will be provided. The manufacturer shall be responsible for and shall provide all control and interlock wiring for the entire system including the chiller control system and communication module provided by the chiller manufacturer. Diagrams shall clearly show how the manufacturer's controls and other devices will be interfaced with all of the equipment installed under this contract requiring connections to the control system.
9. After each Air Terminal Unit (ATU) has been field set at its design operating position, the ATC Contractor shall revise the program logic of each ATU so that future ATU calibration is scheduled during the unoccupied mode.
10. The ATC Contractor shall be responsible for ensuring that the room numbers assigned to all control components such as ATU'S, sensors, thermostats etc in the program logic are the actual room numbers used in the Building prior to the system being turned over to Owner.
11. Sensors not utilized as inputs for control shall be utilized for monitoring AHU parameters through the DDC system.
    a. Setpoints shall be variables in the DDC programs and adjustable by the operator.
12. General Safeties & Alarms:
    a. Upon detection of equipment (fan or coil pump) failure as sensed by its respective current sensing relay, alarms shall be annunciated through the DDC system.

B. Precision Cooling Unit (PCU-1):
1. General:
    a. Units shall be individually controlled by "START-STOP" and "OCCUPIED-UNOCCUPIED" functions of the DDC system. DDC software menus shall allow the operator to override all mode, schedules, and functions. When indexed to "STOP", the PCU is off and controls are returned to their fail-safe position. When indexed to "START", the PCU shall operate in "OCCUPIED" or "UNOCCUPIED" mode as determined through the occupancy schedule program of the DDC system.
    b. Cooling and Heating Seasons: The intent of the system is to maintain cooling season criteria for two months, transition for four months to heating season criteria, maintain heating criteria for two months, and transition for four months back to the cooling season criteria
    c. PCU controls shall generally be furnished by unit manufacturer but with inputs from field devices and sensors provided by BAS contractor. BAS Contractor shall be responsible for installing the manufacturer furnished sensor/controller, and for providing all wiring between devices/sensors and the PCU as required to achieve the specified control sequences.
    d. Upon sensing a high condensate level as sensed by CP-PCU, an alarm shall be annunciated through the DDC system and the glycol cooling system shall be de-energized through DDC command.

2. Occupied Mode:
   a. Fan shall start and run continuously through its ECM type motor, or integral VFC-controlled motor. Fan speed shall modulate to maintain supply duct static pressure setpoint as sensed by static pressure sensing station SPS-SA. Upon SPS-1-1 failure or reading near 0, an alarm shall be annunciated through the DDC system, and SPS shall be removed from the logic and fan shall be controlled to it's prior position. Control setpoint shall be as determined by the project test and balance contractor and shall be lowest value required for each terminal unit to deliver its design flow at system maximum flow.
   b. Temperature Control: PCU shall be cycled through manufacturer furnished controls of its cooling system, free economizer cooling coil, and hot gas reheat coil in order to maintain the supply air discharge temperature setpoint (53 deg F, adjustable) as sense by temperature sensor TS-SA.
      1) Supply air temperature reset: Supply air temperature shall be reset between 53°F (adjustable) and 60°F (adjustable), based on return air temperature (TS-RA). Supply air temperature shall be at minimum value when return air is 2°F (adjustable) above average space temperature setpoint and supply air temperature shall be at maximum value when return air is 3°F (adjustable) below average space temperature setpoint.
   c. Minimum Humidity Control: Minimum humidity control shall be enabled during heating season when Collection Storage humidity sensor HS-1 falls to 5% below setpoint (adjustable). Upon proof of supply airflow by humidifier airflow proving switch, humidifier control loop shall be energized. The DDC system shall energize humidifier H-1 and humidifier shall operate per its manufacturer provided controls to maintain average discharge relative humidity at 60 percent RH (adjustable), as sensed by discharge humidity sensor HS-SA. Setpoint shall be reset as needed to maintain space humidity at 40 percent RH (adjustable), as sensed by space sensor HS-1.
   d. Minimum Outside Air Control: Two minutes after unit occupied mode start-up, the DDC system shall open ventilation air damper D-AHU-1. The DDC system shall modulate return damper D-RA closed to maintain minimum outdoor air volume via mixed air from AHU-1 (2,000 CFM, adjustable) as sensed by AFMS-AHU1.
3. Unoccupied mode:
   a. Unit shall be indexed to stop and controls shall return to their normal position.

C. Air Terminal Units:
1. General:
   a. Refer to floor plans for the number and location of terminal units, reheat coils, and perimeter radiation.
   b. Terminal Equipment Controllers (TEC's), damper actuators, and flow transducers shall be furnished by the ATC contractor to the terminal unit manufacturer for factory mounting.
   c. The ATC contractor shall provide 24v AC transformers and wiring to the TEC's as required for operation of the TEC's and extend 120 volt circuits from panel breakers indicated as ATC or spare on the electrical drawings for ATC use to line side of transformers.
   d. Supply terminal units, reheat coils, and perimeter radiation shall be controlled by "Occupied-Unoccupied" functions of the DDC system.

e. Each TEC shall be suitable for pressure independent operation and shall allow monitoring, alarming, and adjustment of space temperature, terminal unit airflow, damper position, and valve position through the DDC system.

f. The DDC system shall monitor and control space carbon dioxide levels as sensed by space carbon dioxide sensors CS-S located adjacent to temperature sensors in select spaces. See floor plans and air terminal equipment schedule control type for application of carbon dioxide sensors.

g. An alarm shall be annunciated through the DDC system when any space carbon dioxide sensor senses a CO2 concentration above 1100 ppm (adjustable) for a period of 15 minutes (adjustable). Alarm must be manually reset.

h. The BAS shall determine space heating and cooling control setpoints (adjustable) through each DC-X in accordance with outside air temperature or time of year as established by Owner. Setpoints shall be adjustable through the BAS and DC-X.

i. Space temperature as sensed by its space sensor shall be monitored by the BAS and the TEC. An alarm shall be annunciated through the DDC system when any space temperature sensor senses a temperature 5 deg F (adjustable) above setpoint or 5 deg F (adjustable) below setpoint.

2. Type 1 & 1A - VAV Supply Terminal Unit with Reheat Coil:

a. General:

1) Control of Type 1 ATU and appurtenances is indicated below; sequence is typical for Type 1A, except as indicated otherwise.

2) Type 1A includes CO_2 sensor and control.

b. Supply Terminal Occupied Mode:

1) Space temperature sensor TS-S on a fall in temperature below setpoint (75 deg F (adjustable) cooling, 70 deg F (adjustable) heating) shall modulate terminal unit damper D-VAV to reduce air from maximum to minimum cooling flow through its pressure independent terminal equipment controller TEC-VAV.

a) When space occupancy sensor does not sense occupancy, the minimum cooling airflow setpoint shall be reset to 0 CFM.

2) On a further fall, after D-VAV has modulated to its minimum position, electric heating coils shall use SCR controls to energize and regulate the heating coil as required to maintain space temperature setpoint.

3) On a rise in temperature above setpoint, the reverse shall occur.

4) Whenever the integral airflow proving switch detects low or no air flow, electric heating coil shall be de-energized

c. Supply Terminal Occupied Minimum Ventilation Over-Ride Control (for Type 1A only):

1) If the space carbon dioxide level is above 1,000 ppm (adjustable) as sensed by space carbon dioxide sensor CS-S, the TEC-VAV shall modulate damper D-VAV open to maintain space carbon dioxide level at a maximum 1,000 ppm (adjustable) as sensed by CS-S. Supply air quantity shall not exceed scheduled maximum cooling airflow setpoint.

2) If the increased airflow to satisfy space carbon dioxide level causes a fall in space temperature, TEC-VAV shall use the SCR controls to energize and regulate the heating coil to satisfy space temperature setpoint.

3) If maximum supply airflow is being delivered to the space and space carbon dioxide level exceeds 1,000 ppm (adjustable) for 10 minutes (adjustable),

the TEC-VAV shall send a signal to the respective AHU controller to increase outside airflow. Refer to AHU Control Sequence.

4) On a fall in space carbon dioxide level below 1,000 ppm (adjustable), the reverse shall occur.

d. Supply Terminal Unoccupied Mode:

1) Space sensors shall report unoccupied temperatures through the DDC system. When respective AHU is scheduled to operate in the unoccupied mode and is energized, the terminal unit shall operate to maintain its unoccupied space temperature setpoints.

a) ATU control shall be similar to that described above in the occupied mode, except space temperature setpoint shall be increased to 85 deg F (adjustable) cooling and decreased to 55 deg F (adjustable) winter.

b) Ventilation (space carbon dioxide level) over-ride control shall be disabled in the scheduled unoccupied mode.

D. Glycol Cooling Air Conditioning System (Dry Cooler DC-1)

1. General:

a. The system shall be controller by Start/Stop functions of the BAS through operator command. The system is generally intended to operate 24 hours/day and 7 days/week.

b. Pump current sensing relays shall signal the BAS to provide operating status of pumps.

c. Temperature sensors TS-CS(G) & TS-CR(G) shall monitor the glycol water loop supply and return temperatures in the system.

d. The BAS Contractor shall install pressure sensors furnished by the glycol feed unit manufacturer, and shall wire pressure sensors back to the feed unit pump controllers.

e. The BAS shall monitor general alarm status at the control panel of the dry cooler.

2. Start Mode:

a. When the system is indexed to start, the lead pump for the glycol loop shall be energized. A BAS software menu shall allow the operator to either select the lead pump manually or from an automatic lead/lag alternation program. When the automatic alternation program is selected, the lead pump status shall rotate on a weekly basis. Upon failure of the lead pump as sensed by its respective current sensing relay, an alarm shall be annunciated through the BAS and the lag pump shall be started.

b. The BAS shall output a remote enable signal to the dry cooler control panel. The dry cooler fans will be cycled through the dry cooler's factory furnished control panel to maintain the glycol supply temperature setpoint (110 deg F, adjustable).

3. Stop Mode:

a. When the system is indexed to stop through the BAS, a remote stop signal shall be output to the dry cooler controller, and the glycol loop pumps shall be deenergized.

E. Fan Coil Units and Cabinet Unit Heaters

1. Integral FCU and CUH controllers shall be connected to the BAS via BACNET interface. Refer to Sections 238219 and 238239 for integral controllers and associated requirements.

F. Miscellaneous Controls:

1. Air Conditioning Units (ACUs):
    a. ACU controls shall be furnished by unit manufacturer. BAS Contractor shall be responsible for installing the manufacturer furnished temperature sensor/controller, and for providing wiring between the controller and the ACU.
    b. The BAS Contractor shall field install the sensor/controller and provide hard-wired connections to the controllers in order to monitor the following points through the BAS:
        1) On-off status
        2) Common trouble alarm
        3) Space temperature
        4) Smoke detection
    c. Temperature Control: ACU shall be controlled through manufacturer furnished controls to maintain space temperature (75 deg F, adjustable).
2. Monitoring of Miscellaneous Equipment and Devices: Certain equipment shall be monitored by the DDC system, refer to the Input/Output Summary Tables at the end of this section for a list of equipment and associated monitoring points. Provide relays and any other ancillary control devices necessary to accomplish the monitoring points.
3. Combination Fire/Smoke Dampers not associated with AHU or Fan Shut-Down: Combination Fire/smoke dampers shall close upon detection of smoke by the associated duct smoke detector. Power and interlock wiring for smoke dampers and detectors is specified in Division 26. Upon detection of smoke by any duct detector, an alarm shall be annunciated through the DDC system.

1.5 INPUT/OUTPUT (I/O) SUMMARY TABLES

A. Where analog outputs are indicated on the I/O Tables, provide analog outputs. Use of floating digital control for analog outputs is not acceptable.

B. The following page of I/O Tables complete this section.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION (Not Applicable)

END OF SECTION

SYSTEM, APPARATUS, OR AREA POINT DESCRIPTION	INPUTS																					OUTPUTS										SYSTEM FEATURES														GENERAL			NOTES
	ANALOG														BINARY							DIGITAL					ANALOG					ALARMS					PROGRAMS												
	MEASURED									CALC.																																							
	TEMPERATURE	DIFF. PRESSURE	STATIC PRESSURE	RH	POSITION	AIR FLOW (CFM)	FLUID FLOW (GPM, CF	% SPEED VFC		KWH	DEW POINT	RUN TIME	EFFICIENCY	GALLONS, CUBIC FEE	STATUS	FILTER	SMOKE	METER	UNOCC. OVERRIDE	DAMPER POS.	FAULT	OFF-ON	OFF-AUTO-ON	OFF-SLOW-FAST	STAGE CONTROL	OPEN-CLOSE	DAMPER POS.	VALVE POS.	SET POINT ADJ.	SCR CONTROL	FREQ. CONTROLLER	HIGH ANALOG	LOW ANALOG	HIGH BINARY	LOW BINARY	PROOF	TIME SCHED.	DEMAND LIMIT	DUTY CYCLE	START/STOP OPT.	OA ECONOMIZER	OCC / UNOCC	DDC	ALARM INSTRUCT.	MAINT WK ORD.	COLOR GRAPHIC	BACNET INTERFACE		
Precision Cooling Unit PCU-1:					•							•										•														•						•	•			•	•		Note 2
SF-PCU1, CR-PCU1															•														•							•													
TS-SA	•																																																
HS-SA				•																																													
TS-RA	•																																																
TS-AHU-1	•																																																
TS-EAT	•																																																
CP-FCU (High Level Condensate)															•																												•					
D-AHU1																																																	
D-RA																																																	
AFMS-AHU1																																																	
SPS-SA																																																	
Humidifier H-1															•						•									•						•													
HS-1				•																												•	•																
HS-2				•																												•	•																
Terminal Unit (Type 1):																																										•	•			•			
D-VAV																											•																						
TS-S (space sensor)	•																												•			•	•																
TS-D (disch air)	•																																																
Velocity Sensor						•																																											
SCR (Reheat coil)															•						•							•		•														•					
Terminal Unit (Type 1A):																																										•	•			•			
D-VAV																											•																						
TS-S (space sensor)	•																												•			•	•																
TS-D (disch air)	•																																																
Velocity Sensor						•																																											
SCR (Reheat coil)															•						•							•		•														•					
CS-S (Carbon Dioxide Sensor)									•																																								
Water Leak-Detection Systems																					•																									•			Note 3
Glycol Cooling System:																																														•			
DC-1, CR-DC1															•						•																										•		
P-PCU1-1, CR-P-PCU1-1												•			•								•													•													
P-PCU1-1, CR-P-PCU1-1												•			•								•													•													
Flow Meter CW(G)							•				•																						•																
TS-CS(G)	•																															•	•																
TS-CR(G)	•																															•	•																

NOTES:

1. Points indicated shall be typical for all (multiple) pieces of equipment.
2. Connect to BAS via BACNET interface. Map all available monitoring and control points
3. Refer to drawings for location and extent of water detection systems.

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. This Section includes piping, special-duty valves, and hydronic specialties for condenser water systems; makeup water for these systems; blowdown drain lines; steam humidifier manifold supply and condensate drain piping.

B. Related Sections include the following:
   1. Section 230519 “Meters and Gages for Mechanical Piping" for thermometers, pressure gages, and thermowells.
   2. Section 230553 “Identification for Mechanical" for labeling and identifying hydronic piping.
   3. Section 230900 "Instrumentation and Control for HVAC" for temperature-control valves and sensors.
   4. Section 232123 "Hydronic Pumps" for pumps, motors, and accessories for hydronic piping.
   5. Section 232500 “HVAC Water Treatment” for feeder and other treatment.
   6. Most of the mechanical systems are included in the Commissioning Program. Refer to the following specification sections for requirements associated with Commissioning:
      a. Section 019113 “General Commissioning Requirements.”
      b. Section 230800 “Commissioning of Mechanical Systems.”

1.3 DEFINITIONS

A. PVC: Polyvinyl chloride.

1.4 SUBMITTALS

A. Product Data:
   1. For each type of pipe, fitting, and joint indicated.
   2. For each type of hydronic specialty.
   3. For each type of special-duty valve indicated. Include flow and pressure drop curves based on manufacturer's testing for calibrated balancing valves.

B. Shop Drawings: Detail fabrication of pipe anchors, hangers, special pipe support assemblies, alignment guides, expansion joints and loops, and their attachment to the building structure. Detail location of anchors, alignment guides, and expansion joints and loops.

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

D. Field Test Reports: Written reports of tests specified in Part 3 of this Section. Include the following:

1. Test procedures used.
2. Test results that comply with requirements.
3. Failed test results and corrective action taken to achieve requirements.

E. Pipe Cleaning/Flushing Reports.

F. Maintenance Data: For hydronic specialties and special-duty valves to include in maintenance manuals specified in Section 01 78 23 “Operation and Maintenance Data.”.

1.5 QUALITY ASSURANCE

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

B. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.

1.6 COORDINATION

A. Coordinate layout and installation of hydronic piping and suspension system components with other construction, including building structure, electrical conduit and raceway systems, light fixtures, HVAC equipment, air distribution systems, fire-suppression-system components, and partition assemblies.

B. Coordinate pipe sleeve installations for wall penetrations.

C. Coordinate piping installation with roof curbs, equipment supports, and roof penetrations. Roof specialties are specified in Division 7 Sections.

D. Coordinate pipe fitting pressure classes with products specified in related Sections.

E. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into base. Concrete, reinforcement, and formwork requirements are specified in Division 03 Sections.

F. Coordinate installation of pipe sleeves for penetrations through exterior walls and floor assemblies. Coordinate with requirements for firestopping specified in Section 07 84 13 "Penetration Firestopping” for fire and smoke wall and floor assemblies.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Balancing Valves:
      a. Tour & Andersson / Victaulic.
      b. ITT Bell & Gossett
   2. Balancing Ball Valves:

a. Tour & Andersson / Victaulic, TA Series 78BL.
3. Eccentric Plug Valves:
   a. General Signal; DeZurik Unit.
   b. Milliken Valve Company
4. Safety Valves:
   a. Amtrol, Inc.
   b. Armstrong Pumps, Inc.
   c. Conbraco Industries, Inc.
   d. ITT McDonnell & Miller Div.; ITT Fluid Technology Corp.
   e. Kunkle Valve Division.
   f. Spence Engineering Company, Inc.
5. Expansion Tanks:
   a. Amtrol, Inc.
   b. Armstrong Pumps, Inc.
   c. ITT Bell & Gossett; ITT Fluid Technology Corp.
   d. Patterson.
6. Air Separators and Air Purgers:
   a. Armstrong Pumps, Inc.
   b. ITT Bell & Gossett; ITT Fluid Technology Corp.
   c. Spirotherm.
7. Flowmeter Fittings:
   a. Badger Meter, Preso Differential Pressure Meters
   b. Bailey-Fischer & Porter Co.
   c. Barco.
   d. Flow Design, Inc.
   e. Gerand Engineering Co.
   f. Hyspan Precision Products, Inc.
8. Strainers:
   a. Mueller Steam Specialty.
   b. Approved equal.

2.2 PIPING MATERIALS

A. General: Refer to Part 3 "Piping Applications" Article for applications of pipe and fitting materials.

2.3 COPPER TUBE AND FITTINGS

A. Drawn-Temper Copper Tubing: ASTM B 88, Type L.

B. DWV Copper Tubing: ASTM B 306, Type DWV.

C. Wrought-Copper Fittings: ASME B16.22.

D. Wrought-Copper Unions: ASME B16.22 with red bronze ring nut.

E. Copper or Cast Bronze Flanges: ASME B 16.24, including bolts, nuts, and gaskets of the following:
   1. Facings: Raised face.
   2. Class: Equal to adjacent flange of valve or appurtenance.

F. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

G. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BAg-1, silver alloy for joining copper with bronze or steel.

2.4 PLASTIC PIPE AND FITTINGS

A. PVC Pressure Plastic Pipe: ASTM D 1785, Schedules 40 and 80, plain ends.

B. Solid-Wall Schedule 40 PVC Pipe: ASTM D 2665, drain, waste, and vent.

C. PVC Pressure Plastic Pipe Fittings: Socket-type pipe fittings, ASTM D 2466 for Schedule 40 pipe; ASTM D 2467 for Schedule 80 pipe.

D. PVC Socket Fittings: ASTM D 2665, made to ASTM D 3311, drain, waste, and vent patterns and to fit Schedule 40 pipe.

E. Adhesive Primer: ASTM F 656.

F. PVC Solvent Cement: ASTM D 2564.

2.5 VALVES

A. Globe, check, ball, and butterfly valves are specified in Section 23 05 23 “General Duty Valves for Mechanical Piping."

B. General valve requirements for valves (actuators, extension necks, etc.) specified in this section are specified in Section 23 05 23 “General Duty Valves for Mechanical Piping”.

C. Refer to Part 3 "Valve Applications" Article for applications of each valve.

D. Balancing Valves, Sizing: Line size, except where valve is outside of manufacturer’s written recommended flow range.
   1. Maximum Permanent Pressure Drop: 2 feet of head.
   2. Minimum Achievable Flow Rate: 2.0 GPM at maximum 2.5 feet of head permanent pressure drop.

E. Balancing Valves, NPS 2 and Smaller: The balancing valves shall be Y-pattern globe style design and all metal parts of nonferrous, pressure die cast, nonporous Ametal, 125-psig working pressure, 250 deg F maximum operating temperature, and having threaded ends. Valves shall have four (4) 360° adjustment turns of the handwheel for precise setting with hidden memory to provide a tamper-proof balancing setting. Handwheel shall have digital readout. The handwheel can be installed in any position without affecting performance.

F. Balancing Ball Valves, NPS 2 and Smaller: Shut-off, throttling, and measuring ball valve with adjustable memory stop. Provide only for Atrium (Type FT1) Finned Tube Radiators. Contractor shall loosen handle screw, perform flow balance, then remove and store handle.

   1. Body and End Face: Lead-free brass.

2. O-Rings: EPDM suitable for service with propylene and ethylene glycol mixtures up to 50% by volume in water.
3. Valve Handle: Zinc plated low carbon steel with a vinyl dip.
4. Blowout Proof Stem: Stainless steel.
5. Ball: Stainless steel
6. Ball Seats: Polytetrafluoroethylene (PTFE).
7. Indexing Handle with Adjustable Memory Stop: Zinc plated carbon steel.
8. Positioning Pin and Dial Scale: UNS S30400.

G. Pressure-Reducing Valves: Diaphragm-operated, bronze or brass body with low inlet pressure check valve, inlet strainer removable without system shutdown, and noncorrosive valve seat and stem. Select valve size, capacity, and operating pressure to suit system. Valve shall be factory set at operating pressure and have capability for field adjustment.

H. Safety Valves: Diaphragm-operated, bronze or brass body with brass and rubber, wetted, internal working parts; shall suit system pressure and heat capacity and shall be field adjustable to pressures indicated on the drawings.

2.6 HYDRONIC SPECIALTIES

A. Manual Air Vent: Bronze body and nonferrous internal parts; 150-psig working pressure; 225 deg F operating temperature; manually operated with screwdriver or thumbscrew; with NPS 1/8 discharge connection and NPS 1/4 inlet connection.
    1. Vents at top of vent chambers or coils shall be 1/4 inch ball valves.

B. Automatic Air Vent: Designed to vent automatically with float principle; bronze body and nonferrous internal parts; 150-psig working pressure; 240 deg F operating temperature; with piped discharge connection and NPS 3/4 inlet connection. Include ball valve upstream of vent connection, complying with Section 23 05 23 “General Duty Valves for Mechanical Piping”. Pipe all automatic air vents indirectly to floor drains or waste piping system.

C. Expansion Tanks: Welded carbon steel, rated for 125-psig working pressure and 240 deg F maximum operating temperature. Separate air charge from system water to maintain design expansion capacity by a full acceptance flexible replaceable bladder securely sealed into tank. Tank to have label indicating bladder pressure rating. Provide pressure gage on air side of tank with isolation valves and charging valve. Include drain fitting and taps for pressure gage and air-charging fitting. Support vertical tanks with steel legs or base; support horizontal tanks with steel saddles. Factory-fabricate and test tank with taps and supports installed and labeled according to the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.

D. Air Separators: Welded black steel; ASME constructed and labeled for 125-psig minimum working pressure and 350 deg F maximum operating temperature; threaded inlet and outlet connections for NPS 2 and smaller; flanged connections for NPS 2-1/2 and larger; threaded blowdown bottom connection; threaded expansion tank/make-up water top connections threaded air vent top connection; high capacity cast-iron body, automatic air vent with ball valve on inlet, 3/4-inch inlet, 3/8 inch outlet. Provide units in sizes for full-system flow capacity.

E. Y-Pattern Strainers: 125-psig working pressure; cast-iron body (ASTM A 126, Class B), flanged ends for NPS 2-1/2 and larger, bronze body, threaded connections for NPS 2 and smaller, bolted cover, perforated stainless-steel basket, and bottom drain connection. Perforations shall not exceed 1/32 inch; at terminal equipment control valves, provide 0.009 fine mesh screens.

2.7 FLOWMETER FITTINGS

A. Description: Differential-pressure design for installation in piping; with calibrated flow-measuring element, separate flowmeter, hoses or tubing, valves, fittings, and conversion chart compatible with flow-measuring element, flowmeter, and system fluid.

B. Construction:
  1. Venturi Body: Bronze, brass, or factory-primed steel, suitable for the piping system; with brass fittings and attached tag with flow conversion data.
    a. Basis-of-design: Preso CV Series
    b. End Connections for NPS 2 and Smaller: Threaded or solder.
    c. End Connections for NPS 2-1/2 and Larger: Flanged or welded.
    d. Pressure and Temperature Plugs with Extensions.
    e. NPS 0.25 Ball Valves with Extensions
  2. Insertion Pitot Tube: 316 stainless steel probe, “y” type brass head, thread-o-let pipe mounting connection suitable for the piping system; with brass fittings and attached tag for flow conversion data.
    a. Basis-of-design: Preso BAR Ellipse
    b. Extension neck for insulated piping systems

C. Pressure Rating: 150 psig.

D. Temperature Rating: 250 deg F.

E. Range: Flow range of flow-measuring element and flowmeter shall cover operating range of equipment or system served.

F. Maximum Permanent Pressure Drop: Two feet of head at design flow rate.

G. Accuracy: Plus or minus 2 percent for water temperatures from 50 to 215 deg. F.

H. Portable Indicators: Differential-pressure type calibrated for connected flowmeter element and having two 12-foot hoses in carrying case. Provide two indicators, with scales for flow ranges within the building.
  1. Scale: Gallons per minute.
  2. Accuracy: Plus or minus 2 percent between 20 and 80 percent of range.

I. Operating Instructions: Include complete instructions with each flowmeter.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. Condenser Water, NPS 2 and Smaller: Aboveground, use Type L drawn-temper copper tubing with soldered joints.

B. Humidifier Manifold Supply, NPS 2 and Smaller: Type L drawn-temper (MED) copper tubing.

C. Piping for Side-Stream Filter Housing and Shot Feeders: Type L drawn-temper copper tubing with soldered joints.

D. Condensate Drain and Equipment Drainage Lines: Type L drawn-temper or DWV copper tubing with soldered joints.

3.2 VALVE APPLICATIONS

A. General-Duty Valve Applications: Unless otherwise indicated, use the following valve types:
   1. Shutoff Duty: Ball, and butterfly valves.
   2. Throttling Duty: Globe, ball, and butterfly valves.
   3. Balancing Duty – 2” and Smaller: Globe balancing valves.
   4. Balancing Duty – 2 1/2” and Larger: Plug valves.

B. Install shutoff duty valves at each branch connection to supply mains, at supply connection to each piece of equipment, unless only one piece of equipment is connected in the branch line. Install balancing valves and flow meter fittings at each branch connection to return mains, at return connections to each piece of equipment, and elsewhere as indicated.

C. Install balancing valves and flow meter fittings in the return water line of each heating or cooling element and elsewhere as required to facilitate system balancing.

D. Install check valves at each pump discharge and elsewhere as required to control flow direction.

E. Install safety valves on hot-water generators and elsewhere as required by the ASME Boiler and Pressure Vessel Code. Install safety-valve discharge piping, without valves, to floor. Comply with the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, for installation requirements.

F. Install pressure-reducing valves on hot-water generators and elsewhere as required to regulate system pressure.

3.3 PIPING INSTALLATIONS

A. Refer to Section 23 05 00 "Common Work Results for Mechanical" for basic piping installation requirements.

B. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

C. 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.

D. Install piping at a uniform grade of 0.2 percent upward in direction of flow.

E. Install equipment drain and condensate drain piping at a uniform grade of 0.5 percent downward in direction of flow.

F. Reduce pipe sizes using eccentric reducer fitting installed with level side up.

G. Unless otherwise indicated, install branch connections to mains using tee fittings in main pipe, with the takeoff coming out the bottom of the main pipe. For up-feed risers, install the takeoff coming out the top of the main pipe.

H. Install strainers on supply side of each control valve, pressure-reducing valve, solenoid valve, in-line pump, and elsewhere as indicated.
1. Install two nipples; ball valve and threaded cap in blowdown connection of strainers. Install NPS ¾ ball valve for strainers NPS 2 and larger; match size of strainer blowoff connection for strainers smaller than NPS 2.
2. Orient strainers in horizontal pipe, with the strainer basket facing down.

I. Anchor piping for proper direction of expansion and contraction.

J. Use long sweep elbows throughout.

K. Install underground PVC piping according to ASTM D 2321.3.

3.4 HANGERS AND SUPPORTS

A. Hanger, support, and anchor devices are specified in Section 23 05 29 “Hangers and Supports for Mechanical Piping and Equipment." Comply with requirements below for maximum spacing of supports.

B. Install the following pipe attachments:
1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet long.
2. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.
5. On plastic pipe, install pads or cushions on bearing surfaces to prevent hanger from scratching pipe.

C. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:
1. NPS 3/4: Maximum span, 7 feet; minimum rod size, 1/4 inch.
2. NPS 1: Maximum span, 7 feet; minimum rod size, 1/4 inch.
3. NPS 1-1/2: Maximum span, 9 feet; minimum rod size, 3/8 inch.
4. NPS 2: Maximum span, 10 feet; minimum rod size, 3/8 inch.

D. Install hangers for drawn-temper copper piping with the following maximum spacing and minimum rod sizes:
1. NPS 3/4: Maximum span, 5 feet; minimum rod size, 1/4 inch.
2. NPS 1: Maximum span, 6 feet; minimum rod size, 1/4 inch.
3. NPS 1-1/2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
4. NPS 2: Maximum span, 8 feet; minimum rod size, 3/8 inch.

E. Plastic Piping Hanger Spacing: Space hangers according to pipe manufacturer's written instructions for service conditions. Avoid point loading. Space and install hangers with the fewest practical rigid anchor points.

F. Support vertical runs at roof, at each floor, and at 10-foot intervals between floors.

3.5 PIPE JOINT CONSTRUCTION

A. Refer to Section 23 05 00 "Common Work Results for Mechanical" for joint construction requirements for soldered and brazed joints in copper tubing; and threaded, welded, and flanged joints in steel piping; and solvent-welded joints for PVC piping.

3.6 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 in mechanical equipment rooms only at high points of system piping, at heat-transfer coils, and elsewhere as required for system air venting. Install shut-off valve at each vent. Extend discharge piping (minimum 1/4 inch annealed copper) to nearest floor drain, service sink, or drain pipe.

C. Install piping to expansion tank with a 2 percent upward slope toward tank.

D. Install air separators where indicated. Install piping to expansion tanks with a 2 percent slope toward tank. Install blowdown piping with ball valve; extend to nearest drain.

E. Install expansion tanks on housekeeping pads. Vent and purge air from hydronic system, and ensure tank is properly charged with air to suit system design requirements.

3.7 FLOWMETER FITTINGS

A. General: Venturi type flow meter fittings, except at pump connections.
   1. At Pump Connections: Pitot tube type.

B. Install flowmeter fittings in accessible positions in piping systems and with at least minimum straight lengths of pipe upstream and downstream from fittings, in accordance with manufacturers written instructions.

3.8 TERMINAL EQUIPMENT CONNECTIONS

A. Install control valves in accessible locations close to connected equipment.

B. Install ports for pressure and temperature gages at coil inlet connections.

3.9 FIELD QUALITY CONTROL

A. Coordinate with the independent testing agency and Owner’s operational personnel to allow for visual inspection and testing.
   1. Refer to Section 23 05 00 “Common Work Results for Mechanical” for requirements for weld testing and inspection by an independent testing agency.

B. Test, flush and clean hydronic piping per Section 23 05 00 “Common Work Results for Mechanical”

C. Prepare hydronic piping according to ASME B31.9 and as follows:
   1. Leave joints, including welds, uninsulated and exposed for examination (as indicated below) 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.
   5. 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.

D. Perform the following tests on hydronic piping:
   1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that’s safe for workers and compatible with piping may be used.
   2. While filling system, use vents installed at high points of system to release trapped air. Use drains installed at low points for complete draining of liquid.
   3. Check expansion tanks to determine they are not air bound and system is full of water.
   4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the design 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 either 90 percent of specified minimum yield strength or 1.7 times "SE" value in Appendix A of ASME B31.9, "Building Services Piping."
   5. After hydrostatic test pressure has been applied for at least 12 hours, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
   6. Prepare and submit a written report of the above testing to the Architect.

E. Most of the mechanical systems are included in the Commissioning Program. Refer to the following specification sections for requirements associated with Commissioning:
   1. Section 01 91 13 “General Commissioning Requirements”.
   2. Section 23 08 00 “Commissioning of Mechanical Systems”.

3.10 ADJUSTING

A. Mark actuator position of pump, coil, and equipment discharge valves after hydronic system balancing has been completed, to permanently indicate final balanced position.

B. Perform these adjustments before operating the system:
   1. Open shut-off valves to fully open position. Close coil bypass valves.
   2. Check pump for proper direction of rotation.
   3. Set automatic fill valves for required system pressure.
   4. Check air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
   5. Set temperature controls so all coils are calling for full flow.
   6. Check and set operating temperatures of boilers, chillers, and cooling towers to design requirements.
   7. Lubricate motors and bearings.

3.11 CLEANING

A. Flush hydronic piping systems with clean water. Remove and clean or replace strainer screens. Flushing shall be witnessed by the Construction Manager. Minimum flushing velocity shall be 6 feet per second. Refer to Section 23 05 00, “Common Work Results for Mechanical” for additional requirements. Prepare report and submit for record.

B. Chemical cleaning is specified in Section 23 25 00 “HVAC Water Treatment.”

END OF SECTION

SECTION 232123 - HYDRONIC PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:
   1. Close-coupled, in-line centrifugal pumps.
   2. Automatic condensate pump units.

B. Related Sections include the following:
   1. Section 230513 “Common Motor Requirements for Mechanical Equipment” for related motor requirements.
   2. Most of the HVAC systems are included in the Commissioning Program. Refer to the following specification sections for requirements associated with Commissioning:
      a. Section 019113 “General Commissioning Requirements.”
      b. Section 230800 “Commissioning of Mechanical Systems.”
      c. Section 230548 “Mechanical Vibration Control” for vibration isolators.

1.3 DEFINITIONS

A. Buna-N: Nitrile rubber.

B. EPDM: Ethylene Propylene Diene Monomer

C. EPT: Ethylene propylene terpolymer.

1.4 SUBMITTALS

A. Product Data: Include certified performance curves and rated capacities, weights (shipping, installed, and operating), pump speed, operating characteristics, furnished specialties, final impeller dimensions, and accessories for each type of product indicated. Indicate pump's operating point on curves (for parallel pumps, include single and parallel operation). Curves shall indicate capacity versus head, impeller diameters, efficiency, and brake horsepower, for full range (from shut-off head to free delivery). Include suction diffuser inlet and outlet size and pressure drop curves for each end suction pump.

B. Shop Drawings: Show pump layout and connections. Include setting drawings with templates for installing foundation and anchor bolts and other anchorages.
   1. Wiring Diagrams: Power, signal, and control wiring.

C. Manufacturer Statement: Include statement of understanding that coupling furnished on pumps served by VFCs are fully compatible and suitable for VFC service.

D. Pump Alignment Reports.

E. Operation and Maintenance Data: For pumps to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain hydronic pumps through one source from a single manufacturer.

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. UL Compliance: Comply with UL 778 for motor-operated water pumps.

D. Pump Standards: Hydronic Institute
1. HI 1.1-1.5-00 Centrifugal Pumps for Nomenclature, Definitions, Application and Operation (ANSI).
2. HI 2.1-2.5-00 Vertical Pumps for Nomenclature, Definitions, Application and Operation (ANSI).

1.6 DELIVERY, STORAGE, AND HANDLING

A. Manufacturer's Preparation for Shipping: Clean flanges and exposed machined metal surfaces and treat with anticorrosion compound after assembly and testing. Protect flanges, pipe openings, and nozzles with wooden flange covers or with screwed-in plugs.

B. Store pumps in dry location.

C. Retain protective covers for flanges and protective coatings during storage.

D. Protect bearings and couplings against damage from sand, grit, and other foreign matter.

E. Comply with pump manufacturer's written rigging instructions.

1.7 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles below where titles introduce lists, the following requirements apply to product selection:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 GENERAL PUMP REQUIREMENTS

A. Pump Units: Factory assembled and tested.

B. Motors: Comply with requirements in Section 23 05 13 “Common Motor Requirements for Mechanical Equipment.” Motors shall be non-overloading with respect to nameplate horsepower throughout the impeller performance curve.

C. Pumps shall be selected so that the operating point on the selected impeller curve will be at or to the left of, and not more than 5 percent below the point of maximum efficiency. Impeller size for specified duty shall not exceed 85 percent of volute diameter.

2.3 CLOSE-COUPLED, IN-LINE CENTRIFUGAL PUMPS (TYPE IL)

A. Manufacturers:
   1. Basis of Design: Bell & Gossett; Div. of ITT Industries.
   2. Armstrong Pumps Inc.
   3. Aurora Pump; Division of Pentair Pump Group.
   4. Patterson.

B. Description: Centrifugal, overhung-impeller, close-coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally or vertically. Rate pump for 125-psig minimum working pressure and a continuous water temperature of 225 deg F.

C. Pump Construction:
   1. Casing: Radially split, cast iron, with replaceable bronze wear rings, threaded gage tappings at inlet and outlet, and threaded companion-flange or union end connections.
   2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. Trim impeller to match specified performance.
   3. Pump Shaft: Steel, with copper-alloy shaft sleeve.
   4. Mechanical Seal: Carbon rotating ring against a ceramic seat held by a stainless-steel spring, and Buna-N bellows and gasket. Include water slinger on shaft between motor and seal.
   5. Pump Bearings: Permanently lubricated; ball bearings.

D. Motor: Single speed, with grease-lubricated ball bearings, unless otherwise indicated; and rigidly mounted to pump casing.

2.4 AUTOMATIC CONDENSATE PUMP UNITS

A. Manufacturers:
   1. Aurora Pump; Division of Pentair Pump Group.
   2. Beckett Corporation.
   3. Hartell Pumps Div.; Milton Roy Co.
   4. Little Giant Pump Co.; Subsidiary of Tecumseh Products Co.
   5. MEPCO (Marshall Engineered Products Co.).

B. Description: Factory-packaged units with corrosion-resistant pump, plastic tank with cover, rubber mounting feet, thermal overload protection, external tank anti-sweat switch, external test/run lever, check valve, high level shutoff switch (wired to close CHW valve upon activation), and automatic controls.

1. For units located above ceilings, unit shall be hard-wired.
2. For all other locations, provide 6-foot long 120-volt power cord with NEMA 5-15P plug.

C. Minimum Capacity: 40 GPH at 15 feet w.g. head or as otherwise indicated on drawings.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine equipment foundations and anchor-bolt locations for compliance with requirements for installation tolerances and other conditions affecting performance of work.

B. Examine roughing-in for piping systems to verify actual locations of piping connections before pump installation.

C. Examine foundations and inertia bases for suitable conditions where pumps are to be installed.

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

3.2 PUMP INSTALLATION

A. Comply with HI 1.4 and HI 2.4.

B. Install pumps with access for periodic maintenance including removal of motors, impellers, couplings, and accessories.

C. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.

1. Support pump suction diffusers on pump inertia base.

D. Install close coupled in-line pumps with continuous-thread hanger rods and vibration isolation hangers of sufficient size to support pump weight. Vibration isolation devices are specified in Section 23 05 48 "Mechanical Vibration Control." Fabricate brackets or supports as required. Hanger and support materials are specified in Section 23 05 29 “Hangers and Supports for Mechanical Piping and Equipment."

E. Automatic Condensate Pump Units: Install units for collecting condensate and extend to open drain or to sloped, gravity condensate drain main – refer to floor plans for termination point. Vibration isolation devices are specified in Section 23 05 48 “Mechanical Vibration Control."

F. Refer to installation details on drawings for additional requirements.

3.3 ALIGNMENT

A. Engage a factory-authorized service representative to supervise pump alignment.

B. Align pump and motor shafts and piping connections after setting on foundation, grout has been set and foundation bolts have been tightened, and piping connections have been made.

C. Comply with pump and coupling manufacturers' written instructions.

D. Adjust pump and motor shafts for angular and offset alignment by methods specified in HI 1.1-1.5, "Centrifugal Pumps for Nomenclature, Definitions, Application and Operation and HI 2.1-2.5, "Vertical Pumps for Nomenclature, Definitions, Application and Operation."

E. After alignment is correct, tighten foundation bolts evenly but not too firmly. Completely fill baseplate with nonshrink, nonmetallic grout while metal blocks and shims or wedges are in place. After grout has cured, fully tighten foundation bolts.

F. Prepare report and submit for record.

3.4 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to machine to allow service and maintenance.

C. Connect piping to pumps. Install valves that are same size as piping connected to pumps.

D. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.

E. Install flexible connectors on suction and discharge sides of pumps between pump casing and valves.

F. Install drainage piping from pump base mounting frame to floor drain.

G. Install check valve and ball valve on each condensate pump unit discharge.

H. Install electrical connections for power, controls, and devices.

I. Ground equipment according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."

J. Connect wiring according to Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

K. Install flow sensor rings with readout ports on the discharge side of pumps (readout shall be water flow in GPM).

3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.
   1. Complete installation and startup checks according to manufacturer's written instructions.
   2. Check piping connections for tightness.
   3. Remove start-up strainers after systems are flushed clean and replace with permanent strainers.
   4. Perform the following startup checks for each pump before starting:
      a. Verify bearing lubrication.

b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
c. Verify that pump is rotating in the correct direction.
5. Prime pump by opening suction valves and closing drains, and prepare pump for operation.
6. Start motor.
7. Open discharge valve slowly.

3.6 COMMISSIONING

A. Most of the HVAC systems are included in the Commissioning Program. Refer to the following specification sections for requirements associated with Commissioning:
1. Section 01 91 13 “General Commissioning Requirements”.

3.7 DEMONSTRATION

A. Refer to Section 01 73 50 “Demonstration and Training” for training requirements for Owner’s maintenance personnel and building occupants.

END OF SECTION

SECTION 232500 - HVAC WATER TREATMENT

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 water-treatment systems for the following:
   1. Glycol Cooling water piping (closed system).

B. This section also includes glycol.

C. Related Sections include the following:
   1. Most of the mechanical systems are included in the Commissioning Program. Refer to the following specification sections for requirements associated with Commissioning:
      a. Section 01 9113 “General Commissioning Requirements.”
      b. Section 23 0800 “Commissioning of Mechanical Systems.”

1.3 DEFINITIONS

A. PPM: Parts per million.

1.4 CHEMICAL FEED SYSTEM DESCRIPTION

A. Closed-Loop System: One bypass feeder on each system with isolating and drain valves downstream from circulating pumps, unless otherwise indicated.
   1. Introduce chemical treatment through bypass feeder when required or indicated by test.

1.5 PERFORMANCE REQUIREMENTS

A. Maintain water quality for HVAC systems that controls corrosion and build-up of scale and biological growth for maximum efficiency of installed equipment without posing a hazard to operating personnel or the environment.

B. Base chemical treatment performance requirements on quality of water available at Project site, HVAC system equipment material characteristics and functional performance characteristics, operating personnel capabilities, and requirements and guidelines of authorities having jurisdiction.

C. All chemicals proposed for use in this water treatment program shall meet all regulations of the Food and Drug Administration, the United States Environmental Protection Agency and the State Department of Water Resources.

D. Closed System: Maintain system essentially free of scale, corrosion, and fouling to sustain the following water characteristics:

1. pH: 8.0 to 9.5
2. Glycol Cooling (Drycooler) Piping: Use inhibited glycol solution.
3. Tolytriazole: 3 to 6 ppm
4. Dispersant: As needed

1.6 SUBMITTALS

A. Product Data: Include rated capacities; water-pressure drops; shipping, installed, and operating weights; and furnished products listed below:
   1. Chemical solution tanks.
   2. Agitators.
   3. Control equipment and devices.
   4. Test equipment.
   5. Chemicals.
   6. Filters.
   7. Chemical feeders.
   8. Glycol solution.
   9. Glycol feeder units.
   10. Material Safety Data Sheets.

B. Shop Drawings: Detail equipment assemblies indicating dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   1. Wiring Diagrams: Detail power and control wiring and differentiate between manufacturer-installed and field-installed wiring.

C. Water Analysis: Submit a copy of the water analysis to illustrate water quality available at Project site.

D. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

E. Pipe Cleaning Reports.

F. Maintenance Data: For pumps, agitators, filters, system controls, and accessories to include in maintenance manuals specified in Division 1.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: An experienced installer who is an authorized representative of the chemical treatment manufacturer for both installation and maintenance of chemical treatment equipment 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.

1.8 CHEMICAL IDENTIFICATION, HANDLING AND STORAGE

A. The Contractor shall post in one prominent location, complete and updated Material Safety Data Sheets (MSDS) that meet the OSHA hazardous communication standard adjacent to each chemical feed station.

B. The Contractor must maintain a 24 hour, 7 day a week emergency response manned by employees who can be called for emergency information regarding chemical spills and/or accidents involving the Contractor's products. The Contractor shall submit the emergency phone number and a sample of documentation outlining instructions for reporting accidents and chemical spills.

C. All chemicals shall be transported, delivered and installed by the Contractor to the building. Chemicals shall be provided in portable containers properly labeled and marked in accordance with all Federal, State and EPA regulations. University personnel will not handle chemicals. Therefore, the Contractor must deliver all chemicals to the point of use. It is the Contractor's responsibility to transfer and apply all chemicals to the systems at each site.

1.9 MAINTENANCE

A. Scope of Service: Provide chemicals and service program for maintaining optimum conditions in the circulating water for inhibiting corrosion, scale, and organic growths in the cooling water piping and equipment. Services and chemicals shall be provided for a period of two years from date of Substantial Completion, including the following:
   1. Initial water analysis and recommendations.
   2. Startup assistance.
   3. Monthly field service and consultation for each system.
      a. Adjust feeding equipment, apply chemicals, obtain and analyze samples, and regulate bleed-off of open systems to maintain specified performance requirements.
   4. Monthly customer report charts and log sheets for each system.
      a. Indicate which systems were serviced, and then test results.
   5. Laboratory technical assistance.
   6. Analyses and reports of all chemical items concerning safety and compliance with government regulations.
   7. Monthly Legionella Test: Cooling tower water, conducted in a certified laboratory.

1.10 REPORTS

A. The Contractor shall submit reports to the University of Maryland, HVAC Supervisors on an ongoing basis and at the time of each visit. Each report shall contain the following information:
   1. Contractors test results. Test shall be taken for all systems in service at the time of the Contractor's visit. These shall contain all applications test results specified in the chemical residual section of these specifications and or recommended by the manufacturer of the chemical. These results shall be reported in the same units used in the residual section of these specifications.
   2. Results of inspection of water treatment equipment for proper operation.
   3. Inventory of on-hand chemicals for all systems treated.
   4. Water meter readings for all systems with meter.

5. Notation of the overall condition of the systems, chemical feed equipment and anything else that may affect the performance of the treatment program.
6. Note and recommend corrective action for any deficiencies determined by the Contractors test and visual inspection of the systems.
7. Notation of any adjustments made to the system.
8. One copy of the report shall be delivered, discussed and signed off on by the HVAC Manager and one copy shall be left at the inspection/test site. The HVAC Manager's copy must be delivered within five days of the test date.

1.11 EMERGENCY SERVICE

A. The Contractor shall make an emergency job site visit(s) as required by the Owner/Agent to address problems involving water treatment. This shall occur within four (4) hours after the initial call, on 24 hours a day, 7 days a week basis, including holidays. The Contractor shall provide designated Owner/Agent personnel with emergency telephone numbers to call after hours, on weekends and holidays.

1.12 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. Chemicals: Furnish quantity equal to 10 percent of amount initially installed.
   2. Filter Bags: 5 of each listed below.
      a. 5-micron
      b. 20-micron
   3. Glycol: Furnish 50 gallons.

1.13 Coordination

A. Coordinate field piping requirements.

B. Coordinate field wiring requirements.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by the listed manufacturer, no substitutions allowed:
   1. HVAC Water-Treatment Products:
      a. Bond Water Technologies.
      b. Nalco Chemical Co.
      c. Barclay.
      d. Chem Aqua.

2.2 CHEMICAL FEEDING EQUIPMENT

A. Bypass Feeders: Cast iron or steel, for introducing chemicals into system; with 5-micron and 20-micron ring-top filter bags, stainless steel dissolving basket for filter bag support, support legs, wide mouth (minimum 2-inch) opening on top, cap, air-release valve on top, drain valve on bottom, and recirculating shutoff valves on sides. Piping, valves, specialties, and insulation shall be the same specified for the system they serve.

1. Capacity: 5 gal.
2. Working Pressure: 125 psig.

2.3 GLYCOL FEEDER

A. Provide glycol feeder unit as manufactured by Morr Control or approved equal. Glycol feeder shall be designed to provide a consistent operating pressure in closed loop systems so that a controlled percentage of glycol solution can be fed.

B. Unit shall be furnished complete with factory wired and assembled solid-state electronic control unit in a NEMA 1 steel enclosure. A pressure gauge shall be provided to monitor closed loop operating pressure.

C. Unit shall include a preplumbed flow assembly including pressure switch, shut-off valves, Y-strainer, check valve, drum level sensor and pressure relief valve.

D. One positive displacement pump rated at 115 V shall be selected for the system pressure served. A low liquid level switch shall be provided to prevent the pump to operate when solution is low.

E. Provide a vertical polyethylene storage tank with minimum capacity of 50 gallons.

F. Provide all controls, etc., as required and recommended by the manufacturer for a complete installation.

2.4 GLYCOL

A. Provide quantity required to fill drycooler glycol cooling water system.

B. Propylene glycol shall be of the “industrial” type, specially formulated for HVAC duty containing passivating and buffering corrosion inhibitors. Fluid shall be inhibited propylene glycol equal to Dow Dowfrost.

C. The concentration of inhibited glycol solution shall be minimum 30 percent volume for freeze protection at temperatures to 9 deg. F and burst protection at temperatures to –20 deg. F. Glycol shall be purchased pre-mixed to the specified concentrations from the factory. Mixing of glycol with water to obtain the required concentration (other than at the factory) is unacceptable.

PART 3 - EXECUTION

3.1 WATER ANALYSIS

A. Perform an analysis of supply water to determine the type and quantities of chemical treatment needed to maintain the water quality as specified in "Performance Requirements" Article.

3.2 INSTALLATION

A. Install treatment equipment level and plumb.

B. Add cleaning chemicals as recommended by manufacturer.
   1. Cleaning shall be witnessed by the Construction Manager.
   2. Closed recirculating systems shall be filled and sufficient detergent and dispersant added to remove all dirt, oil, and grease. System shall be circulated for at least 24 hours after which drain valve at the lowest point shall be opened and allowed to bleed while the system continues to circulate. The automatic make-up valve shall be checked to be sure it is operating. Bleeding shall continue until water runs clear and all detergent is removed. A sample of water shall be tested and, if pH exceeds the pH of the make-up water, draining shall be resumed.
   3. Before adding cleaning chemical to the closed system, handling coils and fan coil units should be isolated by closing the inlet and outlet valves and opening the by-pass valves, to prevent dirt and solids from lodging in the coils.
   4. After chemical cleaning is satisfactorily completed, open the inlet and outlet valves to each coil and close the bypass valves. Clean strainers.
   5. Prepare report and submit for record.

C. Install glycol in drycooler loop system.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to equipment to allow service and maintenance.

C. Install bypass feeder piping across circulating pump suction and discharge piping.

D. Confirm applicable electrical requirements in Division 26 Sections for connecting electrical equipment.

E. Ground equipment.
   1. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.4 FIELD QUALITY CONTROL

A. Engage a factory-authorized service representative to perform startup service.
   1. Inspect field-assembled components and equipment installation, including piping and electrical connections. Report results in writing.
   2. Inspect piping and equipment to determine that systems and equipment have been cleaned, flushed, and filled with water, and are fully operational before introducing chemicals for water-treatment system.
   3. Place HVAC water-treatment system into operation and calibrate controls during the preliminary phase of HVAC systems' startup procedures.

B. Test chemical feed piping and operation as follows:
   1. Do not enclose, cover, or put piping into operation until it is tested and satisfactory test results are achieved.

2. Test for leaks and defects. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
3. Leave uncovered and unconcealed new, altered, extended, and replaced water piping until it has been tested and approved. Expose work that has been covered or concealed before it has been tested and approved.
4. Cap and subject piping to static water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow test pressure to stand for four hours. Leaks and loss in test pressure constitute defects.
5. Test glycol feeder and automatic feed based on pressure setpoint.
6. Repair leaks and defects with new materials and retest piping until satisfactory results are obtained.
7. Test glycol concentration upon turnover of system to owner at substantial completion.
8. Prepare test reports, including required corrective action.

C. Most of the mechanical systems are included in the Commissioning Program. Refer to the following specification sections for requirements associated with Commissioning:
   1. Section 01 9113 “General Commissioning Requirements”.

3.5 ADJUSTING

A. Occupancy Adjustments: Within 12 months of Substantial Completion, perform two separate water analyses to prove that automatic chemical feed systems are maintaining water quality within performance requirements specified in this Section. Perform analyses at least 60 days apart. Submit written reports of water analysis.

3.6 DEMONSTRATION

A. Refer to Section 01 7350 “Demonstration and Training” for training requirements for Owner’s maintenance personnel and building occupants.

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. This Section includes metal ducts for supply, return, outside, relief, transfer, and exhaust air-distribution systems in pressure classes from minus 10-inch wg to plus 10-inch wg. Metal ducts include the following:
   1. Rectangular ducts and fittings.
   2. Single-wall, round and flat oval, spiral-seam ducts and formed fittings.
   3. Duct liner.

B. Related Sections include the following:
   1. Section 230500 “Common Work Results for Mechanical” for additional general requirements.
   2. Section 230901 “Air Measuring Stations” for air measuring stations furnished under Section 230900, installed under this section.
   3. Section 233300 "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, flexible connectors, and flexible ducts.
   4. Most of the mechanical systems are included in the Commissioning Program. Refer to the following specification sections for requirements associated with Commissioning:
      a. Section 019113 “General Commissioning Requirements.”
   5. Section 230548 “Mechanical Vibration Control” for vibration isolation hangers.

1.3 SYSTEM DESCRIPTION

A. Duct system design, as indicated, has been used to select size and type of air-moving and -distribution equipment and other air system components. Changes to layout or configuration of duct system must be specifically approved in writing by Architect. Accompany requests for layout modifications with calculations showing that proposed layout will provide original design results without increasing system total pressure.

1.4 SUBMITTALS

A. Product Data: Manufacturer’s technical literature for each specified product.

B. Shop Drawings: CAD-generated and drawn to minimum 1/4 inch equals 1-foot scale. Shop Drawings shall be prepared with same building orientation as the construction documents. Show fabrication and installation details for metal ducts.
   1. Include shop drawings for all ductwork provided on this project.
   2. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.

3. Duct layout indicating sizes and pressure classes.
4. Elevations of top and bottom of ducts.
5. Dimensions of main duct runs from building grid lines.
6. Fittings.
7. Penetrations through fire-rated and other partitions.
8. Equipment installation based on equipment being used on Project.
9. Duct accessories, including access doors, panels, dampers, and air flow measuring devices.
10. Hangers and supports, including methods for duct and building attachment, vibration isolation, and seismic restraints.
11. Refer to Section 23 05 00 “Common Work Results for Mechanical” for coordination drawing requirements.

C. Welding certificates.

D. Field quality-control test reports.

E. For each duct system, the gauge, material, joint type, seam type, and reinforcement to be provided for each duct size.

F. No ductwork shall be fabricated or installed until shop drawings are approved.

G. Certificates: For certification required in “QUALITY ASSURANCE” Article.

1.5 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code--Steel," for hangers and supports and AWS D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.

B. NFPA Compliance:
1. NFPA 90A, "Installation of Air Conditioning and Ventilating Systems."
2. NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

C. Duct Cleanliness: Duct Cleanliness for New Construction (SMACNA 2000).

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles below where titles introduce lists, the following requirements apply to product selection:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 SHEET METAL MATERIALS

A. Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible, Third Edition, 2005,” and all addenda 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: Lock-forming quality; complying with ASTM A 653 and having G60 (for circular ducts) and G90 (for rectangular ducts) coating designation; ducts shall have mill-phosphatized finish for surfaces exposed to view in finished spaces, suitable for field painting.

C. 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.

D. Carbon-Steel Sheets: ASTM A 366/A 366M, cold-rolled sheets; commercial quality; with oiled, matte finish for exposed ducts.

E. Stainless Steel: ASTM A 480/A 480M, Type 304, and having a No. 2D finish for concealed ducts and No. 4D finish for exposed ducts.

F. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts.

G. Tie Rods: Galvanized steel, 3/8-inch minimum diameter.

2.3 DUCT LINER

A. Fibrous-Glass Liner: Comply with NFPA 90A or NFPA 90B and with NAIMA AH124.
  1. Manufacturers:
    a. CertainTeed Corp.; Insulation Group.
    b. Johns Manville International, Inc.
    c. Knauf Fiber Glass GmbH.
    d. Owens Corning.
  2. Materials: ASTM C 1071, Type I (flexible) for rectangular ductwork and Type II (rigid) for round ductwork; EPA registered anti-microbial surface coating which will not support the growth of bacteria or fungus; surfaces exposed to airstream shall be coated to prevent erosion of glass fibers.
    a. Thickness: 1-inch or 2-inch, as indicated herein.
    b. Thermal Conductivity (k-Value): 0.24 at 75 deg F mean temperature.
    c. Noise Reduction Coefficient: 0.70 at 1-inch thickness.
    d. Density: Minimum 1.5 pcf.
    e. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.
    f. Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C 916.
      1) Materials shall comply with LEED Credits EQ 4.1 and 4.2 for low emitting materials.
      2) Manufacturers:
        a) Foster 85-60/85-20.
        b) Childers CP-127/CP-82.
    g. Mechanical Fasteners: Galvanized steel suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in duct.

1) Tensile Strength: Indefinitely sustain a 50-lb- tensile, dead-load test perpendicular to duct wall.
2) Fastener Pin Length: As required for thickness of insulation and without projecting more than 1/8 inch into airstream.
3) Adhesive for Attaching Mechanical Fasteners: Comply with fire-hazard classification of duct liner system.

h. Round and flat oval duct liner shall be preformed or round board specifically listed for round and flat oval duct applications.

2.4 SEALANT MATERIALS

A. Joint and Seam Sealants, General: The term "sealant" is not limited to materials of adhesive or mastic nature but includes tapes and combinations of open-weave fabric strips and mastics.

B. Adhesives and sealants applied within the building waterproofing envelope: Comply with low-emitting requirements in Division 01 Section “Indoor Air Quality Requirements.”

C. Rolled Sealant Tape: 3 inches wide for slip joints, 6 inches wide for prefabricated slide-on joints, and formed on flanges; 2 mil aluminum bonded to gray butyl adhesive minimum 30 mils thick, 17 lbs per linear inch peel strength, 720 psi tensile strength, negative 20 deg. F to plus 200 deg. F service temperature, weather resistance per ASTM G-53 @ 2000 hours QUV, suitable for up to 10 inch water gage SMACNA pressure class and all seal classes.

D. Tape Sealing System: Woven-fiber tape impregnated with gypsum mineral compound and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.

E. Water-Based Joint and Seam Sealant: Flexible, adhesive sealant, resistant to UV light when cured, UL 723 listed, and complying with NFPA requirements for Class 1 ducts.

1. Manufacturers:
    a. Foster 32-19 (non-fibrated); 32-17 (fibrated).
    b. Childers CP-146 (non fibrated); CP-148 (fibrated).

F. Solvent-Based Joint and Seam Sealant: One-part, nonsag, solvent-release-curing, polymerized butyl sealant formulated with a minimum of 75 percent solids.

G. Flanged Joint Mastic: One-part, acid-curing, silicone, elastomeric joint sealant complying with ASTM C 920, Type S, Grade NS, Class 25, Use O.

H. Flange Gaskets: Butyl rubber or EPDM polymer with polyisobutylene plasticizer.

2.5 HANGERS AND SUPPORTS

A. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.

B. Hanger Materials: Galvanized sheet steel or threaded steel rod.
   1. Hangers Installed in Corrosive Atmospheres: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.
   2. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for steel sheet width and thickness and for steel rod diameters.
   3. Vibration isolators are specified in Section 23 05 48 “Mechanical Vibration Control.”

C. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

D. Trapeze and Riser Supports: Steel shapes complying with ASTM A 36/A 36M.
   1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
   2. Supports for Stainless-Steel Ducts: Stainless-steel support materials.
   3. Risers: Supports along the long dimension of the duct cross-section, in accordance with SMACNA Manual, Figure 4-7.

E. Round Duct in Finished Spaces: Hangers around full perimeter of ducts with threaded rod supports.

2.6 RECTANGULAR DUCT FABRICATION

A. Fabricate ducts, elbows, transitions, offsets, branch connections, and other construction according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" and complying with requirements for metal thickness, reinforcing types and intervals, tie-rod applications, and joint types and intervals. Fabricate ductwork to be free from vibration, rattle or drumming under all operating conditions.
   1. Lengths: Fabricate rectangular ducts in lengths appropriate to reinforcement and rigidity class required for pressure class.
   2. Deflection: Duct systems shall not exceed deflection limits according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."
   3. Transverse Joints: Utilize prefabricated slide-on joints or formed-on flanges.
      a. Slip-and-Drive Joints may be utilized for transfer ducts, at Contractor’s option.
   4. Materials shall comply with LEED Credits EQ 4.1 and 4.2 for low emitting materials.
   5. Kitchen exhaust hood ductwork shall comply with NFPA 96. Joints, seams, and penetrations of grease ducts shall be made with a continuous liquid-tight weld.
      a. Kitchen exhaust hood ductwork shall be 0.045-inch Type 304, welded stainless steel with finish where exposed to match kitchen equipment and exhaust hood.
      b. Duct joints shall be butt joints, welded flange joints with a maximum flange depth of 1/2 inch or overlapping duct joints of either the telescoping or bell type. Overlapping joints shall be installed to prevent ledges and obstructions from collecting grease or interfering with gravity drainage to the intended collection point. The difference between the inside cross-sectional dimensions of overlapping sections of duct shall not exceed 1/4 inch. The length of overlap for overlapping duct joints shall not exceed 2 inches.

B. Prefabricated Slide-on Joints: Figure 2-1, Slip-on Flange, constructed using manufacturer's guidelines for material thickness, reinforcement size and spacing, joining methods, and joint reinforcement.
   1. Manufacturers:

a. Ductmate Industries, Inc.
b. Nexus, Inc.
c. Quickduc, Inc.
d. Ward Industries, Inc.

C. Formed-On Flanges: Construct according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," Figure 2-1, joints T-25a or T-25b (TDC or TDF) using corner, bolt, cleat, and gasket details.
1. Manufacturers:
a. Ductmate Industries, Inc.
b. Lockformer.
2. Longitudinal Seams: Pittsburgh lock sealed with noncuring polymer sealant.

D. Requirements for Prefabricated Slide-on Joints and Formed-on Flanges:
1. Minimum sheet metal gauges shall conform to both Rectangular Duct Reinforcement Tables 2-1 through 2-28 and Transverse Joint Reinforcement Table 2-32.
2. Cleats or clips as manufactured for the specific purpose of joining adjacent flanges shall be utilized in conjunction with transverse joints; sheet metal screws alone are not acceptable for joining flanges.

E. Restrictions for Use of Tie Rods:
1. Tie rods or other type of intermediate duct reinforcement shall not be used in ducts with longest side less than 37 inches.
2. Where tie rod connections penetrate ductwork, neoprene backed galvanized washers shall be used to seal penetrations airtight.
3. Where tie rods are in sound lined ductwork, seal edges of sound lining penetrations with sound lining adhesive.
4. Tie rods at each joint and between joint and mid span shall align to minimize air turbulence.

F. Rectangular Duct Fittings:
1. Fabricate elbows, transitions, offsets, branch connections, etc., in accordance with SMACNA manual Figures 4-1 through 4-8 and the following:
a. Rectangular elbows shall be Figure 4-2 Type RE-2 with turning vanes. Vanes shall be only single radius type Figures 4-3 and 4-4.
b. Radius elbows shall be Figure 4-2 Type RE-1 only.
c. Branch connections shall be 45-degree entry type only.
d. Transitions and offsets shall follow Figure 4-7 and where space permits shall slope a maximum of 15 degrees, unless otherwise indicated on drawings.

G. Cross Breaking or Cross Beading: Cross break or cross bead duct sides 19 inches and larger and 0.0359 inch thick or less, with more than 10 sq. ft. of nonbraced panel area unless ducts are lined.

2.7 APPLICATION OF LINER IN RECTANGULAR DUCTS

A. Adhere a single layer of indicated thickness of duct liner with 100 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of duct liner is prohibited.

B. Apply adhesive to all transverse edges of liner.

C. Butt transverse joints without gaps and coat joint with adhesive.

D. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.

E. Do not apply liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and standard liner product dimensions make longitudinal joints necessary.

F. Apply adhesive coating on longitudinal seams in ducts.

G. 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.

H. 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:
   1. Fan discharges.
   2. Intervals of lined duct preceding unlined duct.
   3. Upstream edges of transverse joints in ducts where air velocities are greater than 2500 fpm or where indicated.
   4. Branch duct taps.
   5. Duct access doors.

I. 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.

J. Source Quality Control:
   1. Inspect ductwork for compliance with SMACNA manual and NAIMA AH116 “Fibrous Glass Duct Construction Standard.” Repair or replace deficiencies. Utilize NAIMA “Fibrous Glass Duct System Installation Checklist.”
   2. Seal ends of each duct section with plastic in the shop immediately after fabrication to keep airside surfaces clean during handling, shipping, installation, storage, etc.

2.8 ROUND AND FLAT-OVAL DUCT AND FITTING FABRICATION

A. Round and Flat-Oval, Longitudinal- and Spiral Lock-Seam Ducts: Fabricate supply ducts according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible." Fabricate ducts larger than 72 inches in diameter with butt-welded longitudinal seams.
   1. Manufacturers:
      a. Lindab Incorporated.
      b. McGill AirFlow Corporation.
      c. Monroe Metal Manufacturing Company.
      d. SEMCO Incorporated.

B. Materials shall comply with LEED Credits EQ 4.1 and 4.2 for low emitting materials.

C. Duct Joints:
1. Ducts up to 20 Inches in Diameter: Interior, center-beaded slip coupling, sealed before and after fastening, attached with sheet metal screws.
2. Ducts 21 to 72 Inches in Diameter: Three-piece, gasketed, flanged joint consisting of two internal flanges with sealant and one external closure band with gasket.
3. Ducts Larger Than 72 Inches in Diameter: Companion angle flanged joints per SMACNA "HVAC Duct Construction Standards--Metal and Flexible," Figure 3-2.
4. Prefabricated connection system consisting of double-lipped, EPDM rubber gasket. Manufacture ducts according to connection system manufacturer's tolerances.
    a. Manufacturers:
        1) Ductmate Industries, Inc.
        2) Lindab Inc.
5. Flat-Oval Ducts: Prefabricated connection system consisting of two flanges and one synthetic rubber gasket.
    a. Manufacturers:
        1) Ductmate Industries, Inc.
        2) McGill AirFlow Corporation.
        3) SEMCO Incorporated.

D. Fitting Seams:
1. Spot or tack welded and sealed with a specified sealant for pressure classes from minus 2-inch wg to plus 2-inch wg., unless otherwise indicated.
2. Continuously welded for pressure classes from plus 2-inch wg to 10-inch wg., unless otherwise indicated.

E. 90-Degree Tees and Laterals and Conical Tees: Fabricate to comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," with metal thicknesses specified for longitudinal-seam straight ducts. Fittings shall be either “Lo Loss” or conical type. Fabricate with reduced entrance to branch taps and with no excess material projecting from fitting onto branch tap entrance.
1. Saddle taps and bullhead tees are not acceptable.
2. At Contractor’s option, factory fabricated manifolds (one or more “Lo Loss” or conical taps permanently attached to a piece of spiral pipe in the factory) may be provided.

F. Fabricate elbows using die-formed, gored, pleated, or mitered construction. Bend radius of die-formed, gored, and pleated elbows shall be 1-1/2 times duct diameter. Unless elbow construction type is indicated, fabricate elbows as follows:
1. Round Elbows 8 Inches and Less in Diameter: Fabricate die-formed elbows for 45- and 90-degree elbows and pleated elbows for 30, 45, 60, and 90 degrees only. Fabricate nonstandard bend-angle configurations or nonstandard diameter elbows with gored construction.
2. Round Elbows 9 through 14 Inches in Diameter: Fabricate gored or pleated elbows for 30, 45, 60, and 90 degrees unless space restrictions require mitered elbows. Fabricate nonstandard bend-angle configurations or nonstandard diameter elbows with gored construction.
3. Round Elbows Larger Than 14 Inches in Diameter: Fabricate gored elbows unless space restrictions require mitered elbows.

4. 90-Degree, 2-Piece, Mitered Elbows: Use only for supply systems or for material-handling Class A or B exhaust systems and only where space restrictions do not permit using radius elbows. Fabricate with single-thickness turning vanes.
5. Die-Formed Elbow Construction for Sizes through 8 Inches in Diameter and All Pressures: 0.040-inch thick metal with 2-piece welded construction.
6. Pleated Elbow Metal Thickness for Sizes through 14 Inches in Diameter and Pressures through 10-Inch wg: 0.022 inch.
7. Round Gored-Elbow Construction: Welded construction complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," with metal thicknesses specified for longitudinal-seam straight ducts. Minimum number of pieces:
   a. 0 - 45 Degrees: 3.
   b. 46 - 60 Degrees: 4.
   c. 61 - 90 Degrees: 5.
8. Flat-Oval Elbow Construction: Welded construction complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," with thicknesses specified for longitudinal-seam flat-oval duct.
9. Round Mitered Elbow Construction: Welded construction complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," with metal thicknesses specified for longitudinal-seam straight ducts.

G. Round fittings indicated to have sound lining shall be provided with double-wall fittings.

H. End caps of round ductwork exposed in finished spaces shall be convex.

2.9 APPLICATION OF LINER IN ROUND DUCTS

A. Adhere a single layer of indicated thickness of duct liner with 100 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of duct liner is prohibited.

B. Apply adhesive to all transverse edges of liner.

C. Butt transverse joints without gaps and coat joint with adhesive.

D. Preformed liner shall be slid into round duct per manufacturer's installation instructions up to size indicated by manufacturer. Linerboard listed for round duct applications shall be snap-in installation per manufacturer's instructions.

E. Apply adhesive coating on longitudinal seams in ducts.

F. Secure liner in accordance with manufacturer's written recommendations.

G. 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:
1. Fan or terminal unit discharges.
2. Intervals of lined duct preceding unlined duct or fittings.
3. Upstream edges of transverse joints in ducts where air velocities are greater than 2500 fpm (12.7 m/s) or where indicated.

4. Branch duct taps.
5. Duct access doors.

H. 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.

I. At the Contractor’s option, round duct indicated to have sound lining may be provided with double-wall duct.

J. Round fittings indicated to have sound lining shall be provided with double-wall fittings.

PART 3 - EXECUTION

3.1 DUCT APPLICATIONS

A. Static-Pressure and Seal Classes: Unless otherwise indicated on the drawings, construct ducts according to the following:

B.

DUCT SYSTEM	SMACNA PRESSURE CLASS (inches wg)	GAGE PRESSURE	SMACNA SEAL CLASS
Main supply ducts from PCU-1 to terminal units	3”	Positive	A
Supply ducts from terminal units to air devices	2"	Positive	A
Return ductwork from space to units	2"	Negative	A
Transfer ductwork	1”	Positive	None

C. All ducts shall be galvanized steel.

D. All round and flat oval ducts shall be spiral lock-seam type.
1. At Contractor’s option, spiral lockseam duct with standing rib construction may be utilized for concealed positive low pressure (+0 to 2 inch w.g.).
2. At Contractor’s option, when concealed from finished spaces, up to 10 linear feet of longitudinal seam duct may be utilized in low pressure (negative 2-inch w.g. to positive 2-inch w.g.) systems, between taps and diffusers, provided longitudinal seam is sealed.

3.2 DUCT INSTALLATION

A. Construct and install ducts according to SMACNA's "HVAC Duct Construction Standards-Metal and Flexible," unless otherwise indicated.

B. At Contractor’s option, round and flat oval ductwork may be provided in lieu of rectangular duct in equivalent free area sizes where space permits.

C. Install round and flat oval ducts in lengths as long as possible to reduce joints.

D. Install ducts with fewest possible joints.

E. Install fabricated fittings for changes in directions, size, and shape and for connections.

F. Install couplings tight to duct wall surface with a minimum of projections into duct. Secure couplings with sheet metal screws. Install screws at intervals of 12 inches, with a minimum of 3 screws in each coupling.

G. Install ducts, unless otherwise indicated, vertically and horizontally and parallel and perpendicular to building lines; avoid diagonal runs.

H. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

I. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.

J. Conceal ducts from view in finished spaces with suspended ceilings. Do not encase horizontal runs in solid partitions unless specifically indicated.

K. Coordinate layout with suspended ceiling, fire- and smoke-control dampers, lighting layouts, and similar finished work.

L. Seal all joints and seams. Apply sealant to male end connectors before insertion, and afterward to cover entire joint and sheet metal screws.

M. Electrical Equipment Spaces: Route ducts to avoid passing through transformer vaults and electrical equipment spaces and enclosures.

N. Sleeves, Generally: Install minimum 22-gauge galvanized steel sleeves between duct or duct insulation and wall, floor, or ceiling penetrations.
   1. Size sleeve to provide annular space specified or detailed on the drawings.
   2. Seal space outside of sleeves with grout for penetrations of concrete and masonry and with approved sealant for gypsum board assemblies.

O. Floor, Wall, and Partition Penetrations, Generally: Seal annular space between sleeves and duct or duct insulation, using joint sealants appropriate for size, depth, and location of joint.
   1. Where sleeves are exposed in finished spaces, provide 1-inch wide perimeter flange (including corners) on both sides of wall.
   2. There shall be no direct contact of duct with sleeves.
   3. Where ductwork passes through a wall, floor or ceiling, there shall be a clear annular space of 1” between the duct or duct insulation and sleeve. After all of the ductwork is installed the Contractor shall check the clearance, pack the voids full depth with mineral fiber batt insulation and caulk both ends with a non-aging, non-hardening sealant backed by a polyethylene foam rod or permanently flexible firestop material.

P. Non-Fire-Rated Partition Penetrations: Where ducts pass through interior partitions or exterior walls and are exposed to view, conceal spaces between construction openings and ducts or duct insulation with sheet metal flanges of same metal thickness as ducts. Overlap openings on 4 sides by at least 1-1/2 inches.

Q. Fire-Rated Partition Penetrations: Where ducts pass through interior partitions or exterior walls, install appropriately rated fire dampers, sleeves, and firestopping sealant. Fire and smoke dampers are specified in Section 23 33 00 "Air Duct Accessories." Firestopping materials and installation methods are specified in Section 07 84 13 "Penetration Firestopping." Provide sleeves as detailed or required by damper manufacturer.

R. Protect duct interiors from the elements and foreign materials until building is enclosed. Follow SMACNA's "Duct Cleanliness for New Construction."
1. Cleanliness Level: Advanced.
2. Seal ends of ductwork and air devices with plastic as they are installed. In no case shall a duct be left open ended.
3. Once system is placed in operation, provide temporary filters at each return air inlet and at each AHU until final acceptance by the Owner. Refer to Section 23 41 00 “Particulate Air Filtration.”
4. If cleanliness level is not achieved, clean all ductwork to satisfaction of the Architect. Refer to Section 23 01 30.51 for duct cleaning requirements

S. Paint interiors of metal ducts that do not have duct liner, for 24 inches upstream and downstream of registers and grilles. Apply one coat of flat, black, latex finish coat over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Division 9 painting Sections.

T. Paint all ductwork exposed to view in public spaces in color to be submitted for approval by achitect. Provide appropriate galvanized duct finish. Fully remove any fabrication labels or other items from the native finish prior to cleaning, preparing, and finishing the duct with paint. Provide small mock-up of painted ductwork for approval by architect.

U. Install dryer exhaust ducts a minimum 6” from combustible materials.

V. Provide duct cleanout at bottom of dryer exhaust riser.

3.3 SEAM AND JOINT SEALING

A. Seal duct seams and joints according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for duct pressure class indicated.
1. For pressure classes 2-inch wg and lower, seal transverse joints.
2. See paragraph 3.1 for duct seal classes.

B. Seal ducts before external insulation is applied.

C. For ducts without external insulation in finished spaces, utilize tape sealing system.

D. For TDC/TDF and formed-on flange joints, provide sealant along exterior of joints (in addition to the sealant on the flange faces).

3.4 HANGING AND SUPPORTING

A. Support horizontal ducts within 24 inches of each elbow and within 48 inches of each branch intersection.
  1. Exterior Ducts: Maximum 60 inches on center. Design to resist wind loading and up lift.

B. Support vertical ducts at maximum intervals of 16 feet and at each floor.

C. Install upper attachments to structures with an allowable load not exceeding one-fourth of failure (proof-test) load.

D. Install concrete inserts before placing concrete.

E. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
  1. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.

F. Support exterior ductwork in accordance with requirements stated in SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."
  1. Support Spacing: maximum 5 feet.
  2. Support Material: galvanized steel.
  3. Bottom elevation of Exposed Ductwork on Roof: Minimum 5 feet, to facilitate roof access.

G. Install vibration isolation hangers as specified under Section 230548.

3.5 CONNECTIONS

A. Make connections to equipment with flexible connectors according to Section 23 33 00 "Air Duct Accessories."

B. Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.6 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections according to SMACNA's "HVAC Air Duct Leakage Test Manual" and prepare test reports:
  1. Test ALL ductwork.
  2. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
  3. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If pressure classes are not indicated, test entire system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
  4. Maximum Allowable Leakage: Comply with requirements for Leakage Class 3 for round ducts, Leakage Class 6 for rectangular ducts in pressure classes lower than and equal to 2-inch wg (both positive and negative pressures), Leakage Class 6 for rectangular ducts in pressure classes from 2- to 3-inch wg, and Leakage Class 3 for rectangular ducts in pressure classes from 4- to 10-inch wg.

5. Remake leaking joints and retest until leakage is equal to or less than maximum allowable.
6. Keep ducts free of audible leaks that are detectable in finished spaces.
7. Notify Owner's representative and testing and balancing contractor (Section 23 05 93 "Testing, Adjusting, and Balancing for "HVAC"), who shall witness tests, at least 48 hours in advance.
8. Record leakage testing results on reproduced forms from the SMACNA HVAC Air Duct Leakage Test Manual. Submit results of tests to Architect within one week after completion. Maintain a record set of ductwork drawings (on site) with sections of tested ductwork indicated by shading; Commissioning Agent shall periodically inspect record duct testing drawings throughout the construction process.
9. Perform testing prior to installing insulation systems.

B. Installation of Lined Ductwork:
  1. Verify lined duct is free from tears or punctures in facing as each duct section is installed. Repair following NAIMA standard procedures.
  2. Utilize NAIMA "Fibrous Glass Duct System Installation Checklist" as ductwork is installed.
  3. The Owner or their authorized representative intends to inspect the installation of lined duct throughout the construction process to verify conformance with fabrication and installation requirements.

C. Most of the mechanical systems are included in the Commissioning Program. Refer to Section 01 91 13 "General Commissioning Requirements" for requirements associated with Commissioning.

3.7 EXTENT OF SOUND LINING

A. Sound lining for duct systems shall be provided where indicated on drawings.
  1. Sound lining shall be 1" thick.

B. All duct sizes indicated on drawings are airside sizes. Increase sheet metal size as required to accommodate sound lining.

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. This Section includes the following:
1. Volume dampers.
2. Turning vanes.
3. Duct-mounting access doors.
4. Round takeoff fittings.
5. Flexible connectors.
6. Flexible ducts.
7. Duct accessory hardware.

B. Related Sections include the following:
1. Section 01 81 13 “Sustainable Design Requirements” for additional requirements.
2. Section 23 09 00 "Instrumentation and Control for HVAC" for motor-operated dampers.
3. Most of the mechanical systems are included in the Commissioning Program. Refer to the following specification sections for requirements associated with Commissioning:
    a. Section 01 91 13 “General Commissioning Requirements.”

1.3 SUBMITTALS

A. Product Data: For the following:
1. Volume dampers.
2. Turning vanes.
3. Duct-mounting access doors.
4. Round takeoff fittings.
5. Flexible connectors.
6. Flexible ducts.

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. Special fittings.
2. Manual-volume damper installations.
3. Wiring Diagrams: Power, signal, and control wiring.

1.4 QUALITY ASSURANCE

A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

B. Source Limitations: Duct Silencers: Obtain duct silencers through one source from a single manufacturer with resources to provide products complying with requirements indicated without delaying the Work.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles below where titles introduce lists, the following requirements apply to product selection:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 SHEET METAL MATERIALS

A. Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," latest edition for acceptable materials, material thicknesses, and duct construction methods, unless otherwise indicated.

B. Galvanized Sheet Steel: Lock-forming quality; complying with ASTM A 653/A 653M and having G90 coating designation; ducts shall have mill-phosphatized finish for surfaces exposed to view.

C. Stainless Steel: ASTM A 480/A 480M.

D. Aluminum Sheets: ASTM B 209, alloy 3003, temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.

E. Extruded Aluminum: ASTM B 221, alloy 6063, temper T6.

F. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

G. Tie Rods: Galvanized steel, 3/8-inch minimum diameter.

2.3 VOLUME DAMPERS

A. Manufacturers:
   1. Air Balance, Inc.
   2. American Warming and Ventilating.
   3. Flexmaster U.S.A., Inc.
   4. Greenheck Fan Corp.
   5. McGill AirFlow Corporation.
   6. Nailor Industries Inc.
   7. Ruskin Company.

B. General Description: Factory fabricated, with required hardware and accessories. Stiffen damper blades for stability. Include locking device to hold single-blade dampers in a fixed position without vibration. Close duct penetrations for damper components to seal duct consistent with pressure class.

C. Pressure Classes of 3-Inch wg or Higher: End bearings or other seals for ducts with axles full length of damper blades and bearings at both ends of operating shaft.

D. Standard Volume Dampers: Multiple- or single-blade, opposed-blade design, standard leakage rating, and suitable for horizontal or vertical applications.
1. Steel Frames: Hat-shaped, galvanized or stainless (match duct construction) sheet steel channels, minimum of 0.064 inch thick, with mitered and welded corners; frames with flanges where indicated for attaching to walls and flangeless frames where indicated for installing in ducts.
2. Roll-Formed Steel Blades: 0.064-inch- thick, galvanized or stainless (match duct construction) sheet steel.
3. Extruded-Aluminum Blades: 0.050-inch- thick extruded aluminum.
4. Blade Axles: Galvanized steel or Stainless steel (match duct construction).
5. Bearings: Oil-impregnated bronze.
6. Tie Bars and Brackets: Galvanized steel.

E. Manual Remote Control Volume Dampers: Multiple- or single-blade, opposed-blade design as indicated with adjustment cable, standard leakage rating, and suitable for horizontal or vertical applications, as manufactured by Metropolitan Air Technology LLC model #RT-200 (rectangular) and RT-250 (round).
1. Steel Frames: Hat-shaped, galvanized or stainless (match duct construction) sheet steel channels, minimum of 0.064 inch thick, with mitered and welded corners; frames with flanges where indicated for attaching to walls and flangeless frames where indicated for installing in ducts.
2. Roll-Formed Steel Blades: 0.064-inch- thick, galvanized or stainless (match duct construction) sheet steel.
3. Extruded-Aluminum Blades: 0.050-inch- thick extruded aluminum.
4. Blade Axles: Galvanized steel or Stainless steel (match duct construction).
5. Bearings: Self lubricated nylon.
6. Tie Bars and Brackets: Galvanized steel.
7. Actuator:
   a. Worm gear drive with concealed linkage.
   b. Adjustment cable, brass plated; provide length necessary to reach actuator and associated retainers. Adjustable with standard hex nut driver.
   c. Cable Termination: Generally, mounted in linear diffuser plenums. Provide recessed ceiling cup or square air device mounted where installation in linear diffuser plenum is not possible. Recessed ceiling cup size, finish, and location shall be as approved by Architect.

F. Jackshaft: 1/2-inch- diameter, galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
1. Length and Number of Mountings: Appropriate to connect linkage of each damper in multiple-damper assembly.

G. Damper Hardware: Zinc-plated, die-cast core with dial and handle made of 3/32-inch- thick zinc-plated steel, and a 3/4-inch hexagon locking nut. Include center hole to suit damper operating-rod size. Include elevated platform for insulated duct mounting.

2.4 TURNING VANES

A. Fabricate to comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for vanes and vane runners. Vane runners shall automatically align vanes.

B. Manufactured Turning Vanes: Fabricate 1-1/2-inch- wide, single-vane, curved blades of galvanized sheet steel set 3/4 inch o.c.; support with bars perpendicular to blades set 2 inches o.c.; and set into vane runners suitable for duct mounting.
   1. Manufacturers:
      a. Ductmate Industries, Inc.
      b. Duro Dyne Corp.
      c. Ward Industries, Inc.

2.5 DUCT-MOUNTING ACCESS DOORS

A. General Description: Fabricate doors airtight and suitable for duct pressure class.

B. Standard bolted access door: Oval outer door connected to an inner plate by spring loaded carriage bolts, with hand knobs for tightening, inert cellular sponge gasket, and permanently bonded polyester insulation (to prevent moisture from forming on outer surface).
   1. Manufacturers:
      a. American Warming and Ventilating
      b. Ductmate Industries, Inc.
      c. Flexmaster U.S.A., Inc.
      d. Greenheck.
      e. McGill Airflow Corporation.
      f. Nailor Industries, Inc.
      g. Portoff
      h. Ventfabrics, Inc.
      i. Ward Industries, Inc.
   2. Doors shall be leak free at 20” w.g. static pressure.
   3. Doors shall be equal to McGill Airflow Corporation Model AOBXFSDF for rectangular ducts and Model AOBXFSDC for round ducts.

C. Door: Double wall, duct mounting, and round; fabricated of galvanized sheet metal with insulation fill and 1-inch thickness. Include cam latches.
   1. Manufacturers:
      a. Ductmate Industries, Inc.
      b. Flexmaster U.S.A., Inc.
   2. Frame: Galvanized sheet steel, with spin-in notched frame.

D. For round ducts too small to locate other specified access doors, provide hinged access doors.
   1. Manufacturers:
      a. Semco.
      b. Approved equal.
   2. Door shall be 20 gauge galvanized steel.
   3. Hinge shall be continuous type.
   4. Latches shall be sash lock type and a minimum of 3 (one on each side, except hinge side) shall be provided.
   5. Gasket provided shall be continuous.

6. Doors shall be suitable for the pressure class of the duct systems in which they are located.
7. Externally insulate access doors in insulated duct systems. Insulation shall be equal to type and thickness specified for the duct system in Section 23 07 00 “Mechanical Insulation.”
8. Hinged access doors shall be equal to Semco type S40.

2.6 ROUND TAKEOFF FITTINGS

A. Manufacturers:
1. Flexmaster U.S.A., Inc.
2. Approved equal.

B. Provide integral locking hand quadrant type volume damper where indicated or where round takeoff fittings are located at round duct branches serving air devices. Volume damper shall be complete with standoff for 2” insulation, square shaft, U-bolt, nylon bushings, locking quadrant, and damper blade.

C. Seal fittings as follows:
1. Spot or tack welded and sealed with a specified sealant for pressure classes from minus 2-inch wg to plus 2-inch wg, unless otherwise indicated.
2. Continuously welded for pressure classes from plus 2-inch wg to 10-inch wg, unless otherwise indicated.

D. Conical fittings:
1. Spin-in type.
2. Constructed of a two-piece 26-gauge G-90 galvanized steel body and factory sealed for high pressure applications.
3. Overall length of the fitting shall be 6” without damper and 10” with damper.
4. Round outlet shall be provided with a rolled stiffener bead for strength and ease of installation and sealing of spiral and flexible ductwork joints.
5. Conical fittings shall be equal to Flexmaster Model CB.

E. Flared fittings:
1. Spin-in type.
2. Constructed of 26 gauge G-90 galvanized steel.
3. Overall length of the fitting shall be 3” without damper and 7” with damper.
4. Round outlet shall be provided with a rolled stiffener bead for strength and ease of installation and sealing of spiral and flexible ductwork joints.
5. Flared fittings shall be equal to Flexmaster Model FL.

F. Side takeoff fittings:
1. Maintain a ratio of 1:1 of inlet to outlet on units over 7” diameter to allow proper sizing of the duct system.
2. Incorporate a 45-degree rectangular entry to minimize pressure drop.
3. Include a 1” wide pre-punched mounting flange with corner clips and adhesive gasket for minimal leakage and ease of installation.
4. Constructed of a two-piece 26-gauge G-90 galvanized steel body and collar.
5. Overall length of the fitting shall be 13” with or without damper to reduce turbulence in the airstream.

6. Round outlet shall be provided with a rolled stiffener bead for strength and ease of installation and sealing of spiral and flexible ductwork joints.
7. Side takeoff fittings shall be equal to Flexmaster Model STO.

2.7 FLEXIBLE CONNECTORS

A. Manufacturers:
   1. Ductmate Industries, Inc.
   2. Duro Dyne Corp.
   3. Ventfabrics, Inc.
   4. Ward Industries, Inc.

B. General Description: Flame-retardant or noncombustible fabrics, coatings, and adhesives complying with UL 181, Class 1.

C. Extra-Wide Metal-Edged Connectors: Factory fabricated with a fabric strip 5-3/4 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. Select metal compatible with ducts. Fold and crimp metal edge strips onto fabric as illustrated in SMACNA HVAC Duct Standard.

D. 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 20 to plus 200 deg F.

E. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.
   1. Minimum Weight: 24 oz./sq. yd..
   2. Tensile Strength: 530 lbf/inch in the warp and 440 lbf/inch in the filling.
   3. Service Temperature: Minus 10 to plus 250 deg F.

2.8 FLEXIBLE DUCTS

A. Manufacturers:
   1. Atco Rubber Products, Inc.
   2. Flexmaster U.S.A., Inc.
   3. Hart & Cooley, Inc.
   4. McGill AirFlow Corporation.

B. Insulated-Duct Connectors: UL 181, Class 1, 2-ply vinyl film supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene vapor barrier film.
   1. Pressure Rating: 10-inch wg positive and 0.5-inch wg negative.
   2. Maximum Air Velocity: 4000 fpm.
   3. Temperature Range: Minus 10 to plus 140 deg F, continuous.

C. Flexible Duct Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action, in sizes 3 through 18 inches to suit duct size.

D. Flexible Duct Elbows: Provide rigid elbow product for flexible ducts, equivalent to Hart & Cooley Smart Flow Elbow.

2.9 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 and sound lining thickness.

B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

PART 3 - EXECUTION

3.1 APPLICATION AND INSTALLATION

A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards–Metal and Flexible–Second Edition," NAIMA AH124 "Fibrous Glass Duct Liner Standard," and in NAIMA AH116, "Fibrous Glass Duct Construction Standards".

B. Provide 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. Install volume dampers in ducts with liner; avoid damage to and erosion of duct liner.

D. Provide volume dampers at points in supply, return, and exhaust systems where branches lead from larger ducts as required for air balancing. Install at a minimum of two duct widths from branch takeoff. Variations in damper locations (from those indicated in the contract documents) must be approved in writing by the Architect.

E. Provide manual remote control volume dampers where volume dampers are located above inaccessible ceilings (gypsum, plaster, etc.). Locate cable termination points where directed by Architect.

F. Manual remote control volume damper cable installation shall be per manufacturers installation instructions, minimum turn radius of 4”, provide retainers to support bends. Secure cable to building structure to avoid accidental adjustment from other trades.

G. Provide test holes at fan inlets and outlets where indicated and where required for testing and balancing.

H. Install duct round or oval access doors to allow for inspecting, adjusting, and maintaining accessories and terminal units as follows:
1. On both sides of duct coils.
2. On both sides of duct air-flow measuring stations.
3. Adjacent to duct static-pressure measuring probes, providing access for inspection and cleaning.
4. Adjacent to fire or smoke dampers, providing access to reset or reinstall fusible links.
5. Adjacent to duct smoke detectors, providing access for inspection and cleaning.
6. To interior of ducts for cleaning; before and after each change in direction, at maximum 50-foot spacing.

I. Install the following sizes for duct-mounting, oval access doors:
   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.

J. Install the following sizes for duct-mounting, round access doors:
   1. One-Hand or Inspection Access: 8 inches in diameter.
   2. Two-Hand Access: 10 inches in diameter.
   3. Head and Hand Access: 12 inches in diameter.
   4. Head and Shoulders Access: 18 inches in diameter.
   5. Body Access: 24 inches in diameter.

K. Label access doors according to Section 23 05 53 “Identification for Mechanical."

L. Provide round takeoff fitting where round ductwork takes off from rectangular ductwork in accordance with the following:
   1. Provide conical-type fittings where round takeoff is 3" or less than the rectangular duct size.
   2. Provide flared-type fittings where round takeoff size is between 2" and 3" less than the rectangular duct size.
   3. Provide side takeoff fittings where rectangular duct size is not at least 2" greater than round takeoff size.

M. Install metal nosing at duct access doors and duct taps installed in ducts with liner. Seal liner behind nosing with adhesive.

N. Install flexible connectors immediately adjacent to equipment in ducts associated with fans and motorized equipment supported by vibration isolators.

O. For fans developing static pressures of 5-inch wg and higher and for air handling units, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

P. Connect terminal units to supply ducts directly as detailed on drawings. Do not use flexible ducts.

Q. Connect diffusers to low pressure ducts directly or with maximum 60-inch lengths of flexible duct as shown in manufacturer's installation instructions and with 3 wraps of approved tape and stainless steel draw band for tight seal.
   1. Provide rigid flexible duct elbows.
   2. Refer to Section 23 37 13 "Diffusers, Registers, and Grilles" for connection requirements above inaccessible (gypsum, etc.) ceilings.

R. Connect flexible ducts to metal ducts as shown in manufacturer’s installation instructions and with 3 wraps of approved tape and stainless steel draw band for tight seal. For installations above gypsum ceilings, first apply duct sealer to collar before wrapping with tape. Seal insulation with 3 wraps of tape as shown in manufacturer's installation instructions.

S. Install duct test holes where indicated and required for testing and balancing purposes.

3.2 ADJUSTING

A. Adjust duct accessories for proper settings.

B. Final positioning of manual-volume dampers is specified in Section 23 05 93 "Testing, Adjusting, and Balancing for HVAC."

3.3 COMMISSIONING

A. Most of the mechanical systems are included in the Commissioning Program. Refer to the following specification sections for requirements associated with Commissioning:
1. Section 01 91 13 “General Commissioning Requirements.”

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. This Section includes the following:
   1. Shutoff single-duct supply air terminal units.

B. Related Sections include the following:
   1. Section 23 07 00 “Mechanical Insulation” for field-applied acoustical jacketing requirements in noise sensitive areas.
   2. Section 23 09 00 “Instrumentation and Control for HVAC” for controller to be factory-installed under this Section.
   3. Section 23 31 13 “Metal Ducts”.
   4. Most of the mechanical systems are included in the Commissioning Program. Refer to the following specification sections for requirements associated with Commissioning:
      a. Section 01 91 13 “General Commissioning Requirements”.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated, include rated capacities, shipping and operating weights, furnished specialties, air pressure drops, discharge and radiated noise criteria, discharge and radiated sound-power ratings, smoke developed and flame spread ratings, and accessories.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, required clearances, method of field assembly, components, and location and size of each field connection.
   1. Include a schedule showing unique model designation, room location, model number, size, accessories furnished, electrical characteristics, discharge NC, radiated NC, air pressure drop, and coil performance.
   2. Wiring Diagrams: Signal, and control wiring.

C. Operation and Maintenance Data: For air terminal units to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 01 78 20 “Operation and Maintenance Data," include the following:
   1. Instructions for resetting minimum and maximum air volumes.
   2. Instructions for adjusting software set points.

1.4 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of air terminal units and are based on the specific system indicated. Refer to Section 01 60 00 "Product Requirements."

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. NFPA Compliance: Install air terminal units according to NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems."

D. ARI Standard Compliance: Sound data is in accordance with ARI Standard 880-98.

1.5 COORDINATION

A. Coordinate layout and installation of air terminal units 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 with DDC controller furnished in Section 23 09 00 “Instrumentation and Control for HVAC”.

C. Coordinate location of DDC controller and coil connections with structure and adjacent work, maintain recommended manufacturer clearances.

1.6 SELECTION CRITERIA

A. Air terminal units shall be selected for 5 DB lower than the listed Noise Criteria of the Room, for both radiated and discharge sound levels.

B. Noise Criteria of Rooms: NC 30

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

2.2 SHUTOFF SINGLE-DUCT SUPPLY AIR TERMINAL UNITS

A. Manufacturers:
   1. Krueger.
   2. Nailor Industries of Texas Inc.
   3. Price Industries.

4. Titus.
5. Environmental Technologies, Inc.

B. Configuration: Pressure-independent volume-damper assembly inside unit casing, flow sensor, and volume controller with control components located inside a protective metal shroud.

C. Casing: Minimum 22 gauge galvanized steel.
   1. Casing Lining: 1-inch-thick, coated, fibrous-glass duct liner complying with ASTM C 1071 and NFPA 90A; secured with adhesive.
   2. Maximum Casing Leakage: 10 cubic feet per minute at 1-inch wg. inlet static pressure.
   3. Air Inlet: Round stub connection or S-slip and drive connections for duct attachment.
   4. Air Outlet: Rectangular S-slip and drive connections.
   5. Access: Minimum 6-inch by 9-inch removable panels for access to dampers and other parts requiring service, adjustment, or maintenance; with internal lining same thickness as casing lining, and airtight gasket. Access door shall be held in place with screws on maximum 1-inch centers.

D. Regulator Assembly: Extruded-aluminum or galvanized-steel components; key damper blades onto shaft with nylon-fitted pivot points located inside unit casing.
   1. Factory-calibrated and field-adjustable assembly with shaft extension for connection to externally mounted control actuator.

E. Air Flow Sensor: Multi-point cross-shaped type with amplifying pressure pickup points connected to central averaging chamber.
   1. Minimum Differential Pressure Signal: 0.03 inch wg at inlet velocity of 500 fpm.
   2. Sensor Output: Amplified differential pressure signal at least 2.5 times the equivalent velocity pressure signal from a conventional pitot tube.
   3. Compatible with controller.

F. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.
   1. Maximum Damper Leakage: ARI 880 rated, 7 cubic feet per minute at 3-inch wg inlet static pressure.
   2. Damper Position: Normally closed.
   3. Shaft Marker: Permanent, on end of shaft, indicates damper position.
   4. Inlet Pressure Range: 0.05- to 6.0-inches wg.
   5. Key damper blades onto shaft.

G. Electric-Resistance Heating Coils: ETL Listed, Nickel-chromium heating wire, free of expansion noise and hum, mounted in ceramic inserts in a galvanized-steel housing; with primary automatic, and secondary manual, reset thermal cutouts. Terminate elements in stainless-steel, machine-staked terminals secured with stainless-steel hardware.
   1. Proportional SCR controller.
   2. Access door interlocked disconnect switch.
   3. Downstream air temperature sensor with local connection to override discharge-air temperature to not exceed a maximum temperature set point (adjustable).
   4. Nickel chrome 80/20 heating elements.
   5. Airflow switch for proof of airflow.
   6. Fuses in terminal box for overcurrent protection (for coils more than 48 A).
   7. Mercury contactors.

8. Pneumatic-electric switches and relays.
9. Magnetic contactor for each step of control (for three-phase coils)

H. Factory-Fabricated Access Doors: In bottom of units furnished with reheat coils. Minimum 6-inch by 9-inch size, with internal lining same thickness as casing lining, and gasket. Access door shall be held in place with screws on maximum 1-inch centers.

I. DDC Controls: Factory-mount single-package unitary controller and damper actuator specified in Section 23 09 00 "Instrumentation and Control for HVAC." Coordinate with ATC contractor for specific controller to be utilized.

J. Locate controllers and actuators on accessible side of terminal unit, as indicated on drawings.

2.3 SOURCE QUALITY CONTROL

A. Identification: Label each air terminal unit with plan number, nominal airflow, maximum and minimum factory-set airflows, coil type, and ARI certification seal.

B. Verification of Performance: Rate air terminal units according to ARI 880 “Air Terminal test Standard” and ART 885 Application Standard. Rate coils according to ARI 410.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install air terminal units level and plumb. Maintain sufficient clearance for normal service and maintenance.

B. Install air terminal units in accordance with details on drawings and manufacturer’s written recommendations.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to air terminal units to allow service and maintenance.

C. Connect ducts to air terminal units according to Section 23 31 13 "Metal Ducts."

D. Connect wiring according to Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

E. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.3 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:
1. After installing air terminal units and after electrical circuitry has been energized, test for compliance with requirements.
2. Leak Test: After installation, fill water coils and test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Remove and replace malfunctioning units and retest as specified above.

3.4 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.
1. Complete installation and startup checks according to manufacturer's written instructions and do the following:
   a. Verify that inlet duct connections are as recommended by air terminal unit manufacturer to achieve proper performance.
   b. Verify that controls and control enclosure are accessible.
   c. Verify that control connections are complete.
   d. Verify that nameplate and identification tag are visible.
   e. Verify that controls respond to inputs as specified.

3.5 COMMISSIONING

A. Most of the mechanical systems are included in the Commissioning Program. Refer to the following specification sections for requirements associated with Commissioning:
1. Section 01 91 13 “General Commissioning Requirements”.

3.6 DEMONSTRATION

A. Refer to Section 01 73 50 “Demonstration and Training” for training requirements for Owner’s maintenance personnel and building occupants.

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. This Section includes ceiling-, floor-, duct-, and wall-mounted diffusers, registers, and grilles.

B. Related Sections include the following:
  1. Section 08 91 00 "Louvers" for fixed and adjustable louvers and wall vents, whether or not they are connected to ducts.
  2. Section 23 33 00 "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to diffusers, registers, and grilles.

C. Refer to drawings for air devices that will require custom curving to match adjacent walls, ceilings, and floors. Refer to Architectural drawings for radius of curve.

1.3 SUBMITTALS

A. Product Data: For each 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 NC-value noise ratings.
  2. Diffuser, Register, and Grille Schedule: Indicate Drawing designation, room location, quantity, model number, size, accessories furnished, NC-value, pressure drop, and finish.

B. Color Samples: For diffusers, registers, and grilles, Architect to select color.

C. Delete Article below if phased installation of ceiling is not required (to eliminate access doors for volume dampers).

1.4 SELECTION CRITERIA

A. Air devices shall be selected for 5 DB lower than the listed Noise Criteria of the Room.

B. Noise Criteria of Room:
  1. Rooms with NC 30 Criteria: Reading Room, Special Collections.
  2. Rooms with NC 35 Criteria: Lobby all spaces not mentioned in the other NC categories..

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles below where titles introduce lists, the following requirements apply to product selection:
   1. Manufacturers: Subject to compliance with requirements, provide products equal to Basis of Design indicated, by one of the manufacturers specified.

2.2 LINEAR SLOT OUTLETS

A. Linear Flowbar Diffuser High Throw (Type FLD-V):
   1. Basis of Design: Titus FL-HT.
   2. Manufacturers:
      a. Carnes.
      b. Krueger.
      c. Nailor Industries of Texas Inc.
      d. Titus.
      e. Tuttle & Bailey.
      f. Price Industries.
   3. Material: Extruded Aluminum.
   4. Finish – Face: Color selected by Architect.
   5. Finish - Pattern Controller: Baked enamel, black.
   6. Frame: 1 inch flange.
      a. For installations in gypsum ceilings, flange shall be concealed in ceiling (Border Style 22).
   7. Mounting: Concealed bracket.
   8. Pattern Controller: Flat, two-element, steel deflector, adjustment from face of diffuser.
   9. Slot Width: Refer to drawings.
   10. Number of Slots: Refer to drawings.
   11. Accessories: Alignment pins and blank-off strips

2.3 CEILING DIFFUSER OUTLETS

A. Square Panel Ceiling Diffusers (Type CD and CR):
   1. Basis of Design: Titus Model Omni.
   2. Manufacturers:
      a. Carnes.
      b. Krueger.
      c. Nailor Industries of Texas Inc.
      d. Titus.
      e. Tuttle & Bailey.
      f. Price Industries.
   3. Material: 0.034 inch thick Steel.
   4. Finish: Color selected by Architect.
   5. Face Size: 24 by 24 inches (unless indicated otherwise).
   6. Face Style: Architectural panel, single piece, removable.
   7. Mounting: T-bar.
   8. Pattern: Fixed.
   9. Accessories: Directional blow clips.
   10. For Type CR diffusers with Dome:

a. Dome: Transwall Acoustic Dome, Model ACAP or approved equal. 22 gage galvanized steel, factory curved construction, factory blanket insulation constructed of 1.5-inch denim fiber liner and black facing, bonded to interior surface

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, and in accordance with Manufacturer's written instructions.

B. Ceiling- and Wall-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practicable.

1. Refer to the Architectural floor plans, sections, and reflected ceiling plans for exact location of air devices. 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.
2. Ceiling diffuser outlets installed in gypsum ceilings shall not be installed with plaster frames. At the Contractor's option for supply ductwork, flexible duct may be used to connect diffuser to main duct. Diffuser and an adequate amount of hard duct must be supported from the building structure prior to connection with flexible duct for installation of diffuser. Coordinate the installation of the air devices with the sequencing of the gypsum ceiling installation.
3. Support diffusers, registers, grilles, and plenums independently of ceiling construction.

C. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

D. Construct and install duct and plenum connections to diffusers, registers, and grilles in accordance with manufacturer's written instructions.

E. Modify duct systems (transitions, collars, etc.) as required to accommodate actual sizes of grilles, registers, and diffusers.

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 238127 AIR-CONDITIONING UNITS AND DRYCOOLERS

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 air conditioning units (precision cooling units) and drycoolers.

B. Related Sections include the following:
  1. Commissioning of equipment or systems specified in this section is part of the construction process. Documentation and testing of these systems, as well as training of the Owner's operation and maintenance personnel, is required in cooperation with the Commissioning Authority. Project Closeout is dependent on successful completion of all commissioning procedures, documentation, and issue closure.
     a. Refer to Section 01 7700 “Closeout Procedures” for substantial completion details.
     b. Refer to Section 01 9113 “General Commissioning Requirements,” Section 22 0800 “Commissioning of Plumbing Systems,” Section 23 0800 “Commissioning of Mechanical Systems,” and Section 26 0800 “Electrical Systems Commissioning” for detailed commissioning requirements.
     c. Refer to Section 01 7820 “Operation and Maintenance Data” for operations and maintenance data requirements.

1.3 SUBMITTALS

A. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.

B. Shop Drawings: Diagram power, signal, and control wiring.

C. Color Samples for Initial Selection: For units with factory-applied color finishes.

D. LEED Submittal:
  1. Product Data for Credit EA 4: Documentation required by Credit EA 4 indicating that equipment and refrigerants comply.

E. Field quality-control test reports.

F. Operation and Maintenance Data: For air-conditioning units and drycoolers to include in emergency, operation, and maintenance manuals.

G. Warranty: Special warranty specified in this Section.

1.4 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. Energy-Efficiency Ratio: Equal to or greater than prescribed by ASHRAE 90.1, "Energy Efficient Design of New Buildings except Low-Rise Residential Buildings."

C. Coefficient of Performance: Equal to or greater than prescribed by ASHRAE 90.1, "Energy Efficient Design of New Buildings except Low-Rise Residential Buildings."

1.5 COORDINATION

A. Coordinate size, location, and connection details with roof curbs, equipment supports, and roof penetrations specified in Division 7.

1.6 WARRANTY

A. Special Warranty: Manufacturer's standard warranty for parts and workmanship.

PART 2 - PRODUCTS

2.1 AIR-CONDITIONING UNTS

A. Manufacturer: Subject to compliance with requirements, provide units by AboveAir, Liebert Corporation, Data Aire, Stulz, or approved equal.

B. Description: Packaged, factory assembled, prewired, and prepiped split system; with evaporator section consisting of cabinet, supply and return ducted connections, fans, filters, and controls; and separate close-coupled glycol condenser section. Refer to drawings for configuration.

C. Cabinet: Galvanized steel with baked-enamel finish, insulated with 1/2-inch thick duct liner.
   1. Finish of Interior Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.

D. Supply-Air Fan: Forward curved, centrifugal, and directly driven, variable speed by ECM motor or via an integral variable frequency controller.

E. Refrigeration System:
   1. Compressors: minimum of 2 scroll compressors, internal motor overload protection, resilient suspension system, and crankcase heater.
   2. Refrigeration Circuit: Low-pressure switch, manual-reset high-pressure switch, thermal-expansion valve with external equalizer, sight glass with moisture indicator, service shutoff valves, charging valves, and charge of refrigerant.
   3. Refrigerant Evaporator Coil: Direct-expansion coil of seamless copper tubes expanded into aluminum fins.

a. Mount coil assembly over stainless-steel drain pan complying with ASHRAE 62.1-2004 and having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir.

4. Close-coupled, Glycol-Cooled Refrigerant Condenser: Coaxial, counterflow, tube-in-tube type with liquid-line stop valve and head-pressure-actuated, water-regulating valve.
   a. Cooling Medium: 30% propylene glycol solution.
   b. Split system shall have suction- and liquid-line compatible fittings and refrigerant piping for field interconnection.
   c. Cooling Source: Remote, roof mounted, air-cooled, glycol-solution dry-cooler. Refer to Roof Mounted, Air-Cooled, Glycol-Solution Dry-Cooler specified in this Section.
5. Factory-installed water/glycol free cooling cycle complete with economizer cooling coil, aquastat, control logic, and field installed 3-way control valve. The free cooling coil shall be capable of providing rated sensible capacity without compressor operation when entering water/glycol fluid temperatures are 45F or below.

F. Filter: 1-inch-thick, disposable, glass-fiber media and 2” thick pleated MERV 13.

G. Disconnect Switch: Non-automatic, molded-case circuit breaker with handle accessible when panel is closed and capable of preventing access until switched to off position.

H. Control System: Unit-mounted panel with main fan contactor, compressor contactor, compressor start capacitor, control transformer with circuit breaker, solid-state temperature-control modules, time-delay relay, high-temperature thermostat and smoke detector. Provide solid-state, wall-mounted control panel with start-stop switch.
1. BAS Interface: Factory-installed hardware and software to enable the BAS to monitor, and display unit status and alarms via BAcNet Integration.
   a. Hardwired Monitoring Points: On-off status, status alarm, common trouble alarm, space temperature, high/low temperature alarm smoke detection, and smoke alarm.
2. Refer to Section 23 0900 "Instrumentation and Control for HVAC" and Section 23 0993 “Sequence of Operations for HVAC Controls.”

2.2 ROOF MOUNTED, AIR-COOLED, GLYCOL-SOLUTION DRY-COOLER

A. Manufacturer: Subject to compliance with requirements, provide unit by AboveAir, Liebert Corporation, or approved equal..

B. Remote, Air-Cooled, Glycol-Solution Dry-cooler: Corrosion-resistant cabinet, copper-tube 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: Non-automatic, molded-case circuit breaker with handle accessible when panel is closed and capable of preventing access until switched to off position.
2. BAS Interface: Factory-installed hardware and software to enable the BAS to monitor, and display unit status and alarms via BAcNet Integration.
   a. Hardwired Monitoring Points: On-off switch, on-off status, common trouble alarm.
3. Refer to Section 23 0900 "Instrumentation and Control for HVAC" and Section 23 0993 “Sequence of Operations for HVAC Controls.”

2.3 FAN MOTORS

A. Default motor characteristics are specified in Section 23 0513 "Common Motor Requirements for Mechanical Equipment."

B. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 23 0513 "Common Motor Requirements for Mechanical 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 Division 26 Sections.

2.4 ACCESSORIES

A. Automatic-reset timer to prevent rapid cycling of compressor.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install units level and plumb.

B. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.
   1. Refer to Section 23 0548 “Mechanical Vibration Control” for vibration isolator requirements.

C. Install remote mounted sensors. Provide interconnecting wiring.

D. Install ground-mounting, compressor-condenser components on specified support pad. Anchor units to supports.

E. Install roof-mounting compressor-condenser components on equipment supports. Anchor units to supports with removable, cadmium-plated fasteners.
   1. Install roof-mounted compressor-condenser components on vibration isolators. Refer to Section 23 0548 “Mechanical Vibration Control”.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to unit to allow service and maintenance.

C. Ground equipment according to Section 26 0526 “Grounding and Bonding for Electrical Systems.”

D. Electrical Connections: Comply with requirements in Division 26 Sections for power wiring, switches, and motor controls.

3.3 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. 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.

C. Remove and replace malfunctioning units and retest as specified above.

D. System functional performance testing is part of the Commissioning Process. Functional testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority. Refer to Section 01 9113 “General Commissioning Requirements” for system functional tests and commissioning requirements.

3.4 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.
   1. Complete installation and startup checks according to manufacturer's written instructions.

B. Contractors' tests shall be scheduled and documented in accordance with the commissioning requirements. Refer to Section 01 9113 “General Commissioning Requirements,” Section 22 0800 “Commissioning of Plumbing Systems,” Section 23 0800 “Commissioning of Mechanical Systems,” and Section 26 0800 “Electrical System Commissioning” for further details.

3.5 DEMONSTRATION

A. The air conditioning units and drycooler system shall be demonstrated to Owner in all modes of operation. After successful operation is demonstrated, training of maintenance personnel can begin.

B. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain units. Refer to Section 01 7350 “Demonstration and Training.”

C. Training of the owner’s operation and maintenance personnel is required. Provide competent, factory authorized personnel to provide instruction to operation and maintenance personnel concerning the location, operation, and troubleshooting of the installed systems. The instruction shall be scheduled after submission and approval of formal training plans.
   1. Refer to Section 01 7350 “Demonstration and Training” for contractor training requirements.

D. Provide competent, factory authorized personnel to support Owner Training of Commissioned systems. This training is in addition to the contractor Owner's training.
   1. Refer to Section 01 9113 "General Commissioning Requirements," Section 22 0800 "Commissioning of Plumbing Systems," Section 23 0800 "Commissioning of Mechanical Systems," and Section 26 0800 "Electrical System Commissioning" for further contractor training requirements.

3.6 COMMISSIONING

A. Provide support for commissioning activities and functional performance testing as outlined in Section 01 9113 "General Commissioning Requirements."

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:
   1. Self-contained humidifiers.

B. Related Sections include the following:
   1. Section 23 09 00 “Instrumentation and Control for HVAC”.
   2. Commissioning of equipment or systems specified in this section is part of the construction process. Documentation and testing of these systems, as well as training of the Owner’s operation and maintenance personnel, is required in cooperation with the Commissioning Authority. Project Closeout is dependent on successful completion of all commissioning procedures, documentation, and issue closure.
      a. Refer to Section 01 77 00 “Closeout Procedures” for substantial completion details.
      b. Refer to Section 01 91 13 “General Commissioning Requirements,” Section 23 08 00 “Commissioning of Mechanical Systems,” and Section 26 08 00 “Commissioning of Electrical Systems” for detailed commissioning requirements.
      c. Refer to Section 01 78 20 “Operation and Maintenance Data” for operations and maintenance data requirements.

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 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, sections, details of components, manifolds, and attachments to other work.
   1. Wiring Diagrams: Power, signal, and control wiring. Differentiate between manufacturer-installed and field-installed wiring.
   2. Manufacturer’s installation instructions.

C. 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.

D. Field quality-control test reports.

E. Operation and Maintenance Data: For humidifiers to include in operation and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with ARI 640, "Commercial and Industrial Humidifiers."

C. Certifications, C-UL U.S. Listed.

1.6 COORDINATION

A. Coordinate location and installation of humidifiers with manifolds in ducts and air-handling units or occupied space. Revise locations and elevations to suit field conditions and to ensure proper humidifier operation.

B. Delete Article below if not required for project.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Factory-mounted Components: Where humidifier dispersion manifolds specified in this section are indicated to be factory mounted in air handling units, arrange for shipping of humidifiers to unit manufacturer.

PART 2 - PRODUCTS

2.1 ELECTRIC-TO-STEAM HUMIDIFIERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Basis of Design: Nortec Industries Inc., Model NH-EL
2. Armstrong International, Inc.
3. Dri-Steem.
4. Hygromatik; Spirax Sarco, Inc.
5. Trion, Inc.; Herrmidifier Division.

B. Electrode Steam Cylinder: Disposable, spin-welded seams, high water sensor, no internal maintenance, ‘drain through bottom’ design with large perforated strainer to prevent blockage.

C. Steam Dispersion Humidification Panel: ASTM A 666, Type 304 all stainless-steel complete with vertical tubes, horizontal supply header/separator, condensate collection header with drain, and mounting flanges with PVDF insulated high efficiency dispersion tubes for duct-mounted application.

D. Cabinet: Sheet metal enclosure for housing heater cylinder, electrical wiring, components, controls, and control panel. Enclosure shall include baked-enamel finish, hinged or removable access door, and threaded outlet in bottom of cabinet for drain piping.
   1. Adjustable leveling legs.

E. Operation:
   1. Fully-modulating capacity control from 0 to 100% scheduled capacity.
   2. Keep warm function allows the water temperature in the cylinder to be maintained at 160ºF for quick response of the unit to a call for humidity.
   3. Advanced water management utilizing P+I control system to optimize energy efficiency, water usage, and cylinder life.
   4. Internal drain water tempering to ensure maximum 140°F drain water.
   5. Humidifier shall deliver steam to manifold inside air handling unit or air duct.

F. Control Panel:
   1. Factory-wired disconnect switch.
   2. Liquid-crystal display.
   3. Programmable keyboard.
   4. Set-point adjustment.
   5. Warning signal indicating end of replaceable cylinder life.
   6. Low-voltage, control circuit.
   7. Diagnostic, maintenance, alarm, and status features.
   8. High-water sensor or float to prevent overfilling.

G. Controls:
   1. Microprocessor-based control system for modulating (PI control, 0 to 100 percent capacity) control, and start/stop and status monitoring for interface to central HVAC instrumentation and controls.
   2. Solenoid-fill and automatic drain valves to maintain water level and temper hot drain water.
   3. Field-adjustable timer to control drain cycle for flush duration and interval.
   4. Controls shall drain tanks if no demand for humidification for more than 72 hours.
   5. Conductivity-type level controls.
   6. Building Automation System (BAS)Interface: Factory-installed hardware and software to allow the BAS to monitor, control, display and record data for use in preparing reports via BacNet interface. Refer to Section 23 09 00 "Instrumentation and Control for HVAC."

H. Accessories:
   1. Airflow switch (differential pressure type) for preventing humidifier operation without airflow.
   2. Condensate Cooler: Provide adjustable floor-mounted condensate cooler chamber with integral temperature-activated cold water valve to provide tempered water to sanitary drain (140 deg F or less) sized for overflow and drain-down discharge flows.
      a. Condensate cooler below has a maximum capacity to cool 6 GPM of 212 deg F drain water, with a discharge of 12 GPM at 140 deg F.

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.

B. Install manifold supply piping pitched to drain condensate back to humidifier.

C. Install drip leg upstream from steam trap a minimum of 12 inches tall for proper operation of trap.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
   1. Piping shall be sized and installed in strict accordance with manufacturer’s requirements.
   2. Install piping adjacent to humidifiers to allow service and maintenance.
   3. Install shutoff valve, strainer, and union in humidifier supply line.
   4. Install Y connectors where humidifier has two outlet connections.
   5. Connect drain piping with a minimum of 1-inch (25mm) air gap.

B. Ground equipment according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."

C. Connect wiring according to Section 26 05 19 "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. 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.

C. Remove and replace malfunctioning units and retest as specified above.

D. System functional testing is part of the Commissioning Process. Functional testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority. Refer to Section 01 91 13 “General Commissioning Requirements” for system functional tests and commissioning requirements.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain humidifiers. Refer to Section 01 73 50 "Demonstration and Training."
   1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment and schedules.
   2. Review data in maintenance manuals. Refer to Section 01 73 50 “Demonstration and Training.”
   3. Schedule training with Owner, through Architect, with at least seven days' advance notice.

B. Training of the owner’s operation and maintenance personnel is required in cooperation with the Commissioning Authority. Provide competent, factory authorized personnel to provide instruction to operation and maintenance personnel concerning the location, operation, and troubleshooting of the installed systems. The instruction shall be scheduled in coordination with the Commissioning Authority after submission and approval of formal training plans.
   1. Refer to Section 01 73 50 “Demonstration and Training” for contractor training requirements.
   2. Refer to Section 01 91 13 “General Commissioning Requirements,” Section 23 08 00 “Commissioning of Mechanical Systems,” and Section 26 08 00 “Commissioning of Electrical Systems” for further contractor training requirements.

END OF SECTION

SECTION 260519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
1. Copper building wire rated 600 V or less.
2. Connectors, splices, and terminations rated 600 V and less.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Product Schedule: Indicate type, use, location, and termination locations.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA.
1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

PART 2 - PRODUCTS

2.1 COPPER BUILDING WIRE

A. Description: Flexible, insulated and uninsulated, drawn copper current-carrying conductor with an overall insulation layer or jacket, or both, rated 600 V or less.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Cerro Wire LLC.
2. General Cable Technologies Corporation.
3. Service Wire Co.
4. Southwire Company.

C. Standards:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
2. Conductor Marking: Comply with wire marking according to UL's "Wire and Cable Marking and Application Guide."

D. Conductors: Copper, complying with ASTM B 3 for bare annealed copper and with ASTM B 8 for stranded conductors.

E. Conductor Insulation:
1. Type THHN and Type THWN-2: Comply with UL 83.

2.2 CONNECTORS AND SPLICES

A. Description: Factory-fabricated connectors, splices, and lugs of size, ampacity rating, material, type, and class for application and service indicated; listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. 3M Electrical Products.
2. Hubbell Power Systems, Inc.
3. Ideal Industries, Inc.
4. O-Z/Gedney; a brand of Emerson Industrial Automation.
5. Thomas & Betts Corporation.

C. Lugs: One piece, seamless, designed to terminate conductors specified in this Section.
1. Material: Copper.
2. Type: Two hole with standard barrels.
3. Termination: Compression.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders: Copper; solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

B. Branch Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

3.2 CONDUCTOR INSULATION APPLICATIONS AND WIRING METHODS

A. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspaces: Type THHN/THWN-2, single conductors in raceway.

B. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN/THWN-2, single conductors in raceway.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

A. Conceal cables in finished walls, ceilings, and under floors unless otherwise indicated.

B. Complete raceway installation between conductor termination points according to Section 260533 "Raceways and Boxes for Electrical Systems" prior to pulling conductors and cables.

C. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

D. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage conductors or raceway.

E. Minimum wire size is 12 AWG. All circuits greater than 75 feet shall be 10 AWG or larger.

3.4 CONNECTIONS

A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

B. Make splices, terminations, and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches (150 mm) of slack.

3.5 IDENTIFICATION

A. Identify and color-code conductors according to Section 260553 "Identification for Electrical Systems."

B. Identify each spare conductor at each end with identity number and location of other end of conductor, and identify as spare conductor.

3.6 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.7 FIRESTOPPING

A. Provide firestopping for electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Section 078413 "Penetration Firestopping."

3.8 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

1. After installing conductors and before electrical circuitry has been energized, test service entrance and feeder conductors for compliance with requirements.
2. Perform each of the following visual and electrical tests:
   a. Inspect exposed sections of conductor for physical damage and correct connection according to the one-line diagram.
   b. Test bolted connections for high resistance using one of the following:
      1) A low-resistance ohmmeter.
      2) Calibrated torque wrench.
      3) Thermographic survey.
   c. Inspect compression-applied connectors for correct cable match and indentation.
   d. Inspect for correct identification.
   e. Inspect cable jacket and condition.
   f. Insulation-resistance test on each conductor for ground and adjacent conductors. Apply a potential of 500-V dc for 300-V rated cable and 1000-V dc for 600-V rated cable for a one-minute duration.
   g. Continuity test on each conductor.
   h. Uniform resistance of parallel conductors.

C. Conductors will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports to record the following:
   1. Procedures used.
   2. Results that comply with requirements.
   3. Results that do not comply with requirements, and corrective action taken to achieve compliance with requirements.

END OF SECTION

SECTION 260526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes grounding and bonding systems and equipment.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.
   1. Grounding arrangements and connections for separately derived systems.

B. Qualification Data: For testing agency and testing agency's field supervisor.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For grounding to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Certified by NETA.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. ERICO International Corporation.
   2. Fushi Copperweld Inc.
   3. Harger Lightning and Grounding.
   4. ILSCO.
   5. Robbins Lightning, Inc.

2.2 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with UL 467 for grounding and bonding materials and equipment.

2.3 CONDUCTORS

A. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.

B. Bare Copper Conductors:
   1. Solid Conductors: ASTM B 3.
   2. Stranded Conductors: ASTM B 8.
   3. Tinned Conductors: ASTM B 33.
   4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch (6 mm) in diameter.
   5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
   6. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.
   7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.

2.4 CONNECTORS

A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.

B. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

C. Bus-Bar Connectors: Mechanical type, cast silicon bronze, solderless compression-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.

D. Beam Clamps: Mechanical type, terminal, ground wire access from four directions, with dual, tin-plated or silicon bronze bolts.

E. Cable-to-Cable Connectors: Compression type, copper or copper alloy.

F. Conduit Hubs: Mechanical type, terminal with threaded hub.

G. Lay-in Lug Connector: Mechanical type, copper rated for direct burial terminal with set screw.

H. Straps: Solid copper, cast-bronze clamp. Rated for 600 A.

I. Tower Ground Clamps: Mechanical type, copper or copper alloy, terminal one-piece clamp.

J. U-Bolt Clamps: Mechanical type, copper or copper alloy, terminal listed for direct burial.

K. Water Pipe Clamps:
   1. Mechanical type, two pieces with zinc-plated bolts.
      a. Material: Tin-plated aluminum.
      b. Listed for direct burial.
   2. U-bolt type with malleable-iron clamp and copper ground connector.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger unless otherwise indicated.

B. Conductor Terminations and Connections:
   1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
   2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
   3. Connections to Ground Rods at Test Wells: Bolted connectors.
   4. Connections to Structural Steel: Welded connectors.

3.2 GROUNDING AT THE SERVICE

A. Equipment grounding conductors and grounding electrode conductors shall be connected to the ground bus. Install a main bonding jumper between the neutral and ground buses.

3.3 GROUNDING SEPARATELY DERIVED SYSTEMS

A. Generator: Install grounding electrode(s) at the generator location. The electrode shall be connected to the equipment grounding conductor and to the frame of the generator as well as the alternator’s neutral.

3.4 EQUIPMENT GROUNDING

A. Install insulated equipment grounding conductors with all feeders and branch circuits.

B. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:
   1. Feeders and branch circuits.
   2. Lighting circuits.
   3. Receptacle circuits.
   4. Single-phase motor and appliance branch circuits.
   5. Three-phase motor and appliance branch circuits.
   6. Flexible raceway runs.

C. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.

D. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.

3.5 INSTALLATION

A. Grounding Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

B. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.
   1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
   2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
   3. Use exothermic-welded connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.

C. Grounding and Bonding for Piping:
   1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes; use a bolted clamp connector or bolt a lug-type connector to a pipe flange by using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
   2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
   3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.

D. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install tinned bonding jumper to bond across flexible duct connections to achieve continuity.

3.6 FIELD QUALITY CONTROL

A. Perform tests and inspections.
   1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
   2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
   3. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal and at individual ground rods. Make tests at ground rods before any conductors are connected.
      a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
      b. Perform tests by fall-of-potential method according to IEEE 81.

B. Grounding system will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

D. Report measured ground resistances that exceed the following values:
   1. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 ohms.
   2. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.
   3. Power Distribution Units or Panelboards Serving Electronic Equipment: 1 ohm(s).
   4. Substations and Pad-Mounted Equipment: 5 ohms.

E. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

END OF SECTION

SECTION 260529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Steel slotted support systems.
   2. Aluminum slotted support systems.
   3. Nonmetallic slotted support systems.
   4. Conduit support devices.
   5. Support for conductors in vertical conduit.
   6. Structural steel for fabricated supports and restraints.
   7. Mounting, anchoring, and attachment components, including powder-actuated fasteners, mechanical expansion anchors, concrete inserts, clamps, through bolts, toggle bolts, and hanger rods.
   8. Fabricated metal equipment support assemblies.

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 the following:
      a. Slotted support systems, hardware, and accessories.
      b. Clamps.
      c. Hangers.
      d. Sockets.
      e. Eye nuts.
      f. Fasteners.
      g. Anchors.
      h. Saddles.
      i. Brackets.
   2. Include rated capacities and furnished specialties and accessories.

PART 2 - PRODUCTS

2.1 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Preformed steel channels and angles with minimum 13/32-inch- (10-mm-) diameter holes at a maximum of 8 inches (200 mm) o.c. in at least one surface.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Allied Tube & Conduit; a part of Atkore International.
b. Cooper B-Line, Inc.; a division of Cooper Industries.
c. ERICO International Corporation.
d. Thomas & Betts Corporation; A Member of the ABB Group.
e. Unistrut; Part of Atkore International.

2. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
3. Material for Channel, Fittings, and Accessories: Galvanized steel.
4. Channel Width: Selected for applicable load criteria.
5. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.

B. Conduit Support Devices: Steel and malleable-iron hangers, clamps, and associated fittings, designed for types and sizes of raceway to be supported.

C. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for nonarmored electrical conductors in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors supported. Body shall be made of malleable iron.

D. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M steel plates, shapes, and bars; black and galvanized.

E. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:

1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1) Hilti, Inc.
      2) ITW Ramset/Red Head; Illinois Tool Works, Inc.
      3) MKT Fastening, LLC.
      4) Simpson Strong-Tie Co.
2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1) Hilti, Inc.
      2) ITW Ramset/Red Head; Illinois Tool Works, Inc.
      3) MKT Fastening, LLC.
      4) Cooper B-Line, Inc.; a division of Cooper Industries.
3. Concrete Inserts: Steel or malleable-iron, slotted support system units are similar to MSS Type 18 units and comply with MFMA-4 or MSS SP-58.
4. Clamps for Attachment to Steel Structural Elements: MSS SP-58 units are suitable for attached structural element.
5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
6. Toggle Bolts: All-steel springhead type.
7. Hanger Rods: Threaded steel.

2.2 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

A. Description: Welded or bolted structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

B. Materials: Comply with requirements in Section 055000 "Metal Fabrications" for steel shapes and plates.

PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with the following standards for application and installation requirements of hangers and supports, except where requirements on Drawings or in this Section are stricter:
   1. NECA 1, “Standard Practice for Good Workmanship in Electrical Construction.”
   2. NECA 101, “Standard for Installing Steel Conduits.”

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

C. Comply with requirements for raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."

D. Maximum Support Spacing and Minimum Hanger Rod Size for Raceways: Space supports for EMT, and RMC as required by NFPA 70. Minimum rod size shall be 1/4 inch (6 mm) in diameter.

E. Multiple Raceways: Install trapeze-type supports fabricated with steel slottedsupport system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.
   1. Secure raceways to these supports with two-bolt conduit clamps.

3.2 SUPPORT INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this article.

B. Raceway Support Methods: In addition to methods described in NECA 1, EMT, and RMC may be supported by openings through structure members, according to NFPA 70.

C. 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 (90 kg).

D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:
   1. To Wood: Fasten with lag screws or through bolts.

2. To New Concrete: Bolt to concrete inserts.
3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
4. To Existing Concrete: Expansion anchor fasteners.
5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches (100 mm) thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches (100 mm) thick.
6. To Steel: Beam clamps (MSS SP-58, Type 19, 21, 23, 25, or 27), complying with MSS SP-69.
7. To Light Steel: Sheet metal screws.
8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate.

E. Drill holes for expansion anchors in concrete at locations and to depths that avoid the need for reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Comply with installation requirements in Section 055000 "Metal Fabrications" for site-fabricated metal supports.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.

C. Field Welding: Comply with AWS D1.1/D1.1M.

3.4 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
   1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils (0.05 mm).

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

END OF SECTION

SECTION 260533 - RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
1. Metal conduits and fittings.
2. Nonmetallic conduits and fittings.
3. Boxes, enclosures, and cabinets.

B. Related Requirements:
1. Section 078413 "Penetration Firestopping" for firestopping at conduit and box entrances.

1.3 DEFINITIONS

A. GRC: Galvanized rigid steel conduit.

1.4 ACTION SUBMITTALS

A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

PART 2 - PRODUCTS

2.1 METAL CONDUITS AND FITTINGS

A. Metal Conduit:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Allied Tube & Conduit; a part of Atkore International.
   b. Southwire Company.
   c. Western Tube and Conduit Corporation.
2. Listing and Labeling: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. GRC: Comply with ANSI C80.1 and UL 6.
4. EMT: Comply with ANSI C80.3 and UL 797.
5. FMC: Comply with UL 1; zinc-coated steel.
6. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.

B. Metal Fittings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. AFC Cable Systems; a part of Atkore International.
    b. Allied Tube & Conduit; a part of Atkore International.
    c. Anamet Electrical, Inc.
    d. O-Z/Gedney; a brand of Emerson Industrial Automation.
    e. Southwire Company.
2. Comply with NEMA FB 1 and UL 514B.
3. Listing and Labeling: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
4. Fittings, General: Listed and labeled for type of conduit, location, and use.
5. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 1203 and NFPA 70.
6. Fittings for EMT:
    a. Material: Steel.
    b. Type: Compression.
7. Expansion Fittings: Steel to match conduit type, complying with UL 651, rated for environmental conditions where installed, and including flexible external bonding jumper.

C. Joint Compound for GRC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.2 NONMETALLIC CONDUITS AND FITTINGS

A. Nonmetallic Conduit:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. AFC Cable Systems; a part of Atkore International.
    b. CANTEX INC.
    c. Kraloy.
    d. Lamson & Sessions.
    e. Thomas & Betts Corporation; A Member of the ABB Group.
2. Listing and Labeling: Nonmetallic conduit shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. ENT: Comply with NEMA TC 13 and UL 1653.
4. RNC: Type EPC-40-PVC, complying with NEMA TC 2 and UL 651 unless otherwise indicated.
5. LFNC: Comply with UL 1660.

B. Nonmetallic Fittings:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. CANTEX INC.
    b. CertainTeed Corporation.
    c. Kraloy.
    d. Lamson & Sessions.
    e. Thomas & Betts Corporation; A Member of the ABB Group.
2. Fittings, General: Listed and labeled for type of conduit, location, and use.

3. Fittings for ENT and RNC: Comply with NEMA TC 3; match to conduit or tubing type and material.
    a. Fittings for LFNC: Comply with UL 514B.
4. Solvents and Adhesives: As recommended by conduit manufacturer.

2.3 BOXES, ENCLOSURES, AND CABINETS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    1. Crouse-Hinds, an Eaton business.
    2. Hoffman; a brand of Pentair Equipment Protection.
    3. RACO; Hubbell.
    4. Spring City Electrical Manufacturing Company.
    5. Thomas & Betts Corporation; A Member of the ABB Group.

B. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets installed in wet locations shall be listed for use in wet locations.

C. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.

D. Nonmetallic Outlet and Device Boxes: Comply with NEMA OS 2 and UL 514C.

E. Metal Floor Boxes:
    1. Material: sheet metal.
    2. Type: Fully adjustable.
    3. Shape: Round.
    4. Listing and Labeling: Metal floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

F. Luminaire Outlet Boxes: Nonadjustable, designed for attachment of luminaire weighing 50 lb (23 kg). Outlet boxes designed for attachment of luminaires weighing more than 50 lb (23 kg) shall be listed and marked for the maximum allowable weight.

G. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

H. Box extensions used to accommodate new building finishes shall be of same material as recessed box.

I. Device Box Dimensions: 4 inches square by 2-1/8 inches deep (100 mm square by 60 mm deep).

J. Gangable boxes are allowed.

K. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, Type 1 with continuous-hinge cover with flush latch unless otherwise indicated.
    1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
    2. Nonmetallic Enclosures: Fiberglass.
    3. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

A. Outdoors: Apply raceway products as specified below unless otherwise indicated:
   1. Exposed Conduit: GRC.
   2. Concealed Conduit, Aboveground: GRC.
   3. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
   4. Boxes and Enclosures, Aboveground: NEMA 250, Type 4.

B. Indoors: Apply raceway products as specified below unless otherwise indicated:
   1. Exposed, Not Subject to Physical Damage: EMT.
   2. Exposed, Not Subject to Severe Physical Damage: EMT.
   3. Exposed and Subject to Severe Physical Damage: GRC. Raceway locations include the following:
      a. Mechanical rooms.
   4. Concealed in Ceilings and Interior Walls and Partitions: EMT.
   5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
   6. Damp or Wet Locations: GRC.
   7. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4 stainless steel in institutional and commercial kitchens and damp or wet locations.

C. Minimum Raceway Size: 3/4-inch (21-mm) trade size.

D. Raceway Fittings: Compatible with raceways and suitable for use and location.
   1. Rigid Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
   2. EMT: Use compression, steel fittings. Comply with NEMA FB 2.10.
   3. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.

E. Install nonferrous conduit or tubing for circuits operating above 60 Hz. Where aluminum raceways are installed for such circuits and pass through concrete, install in nonmetallic sleeve.

F. Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth.

3.2 INSTALLATION

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for hangers and supports.

B. Comply with NECA 1 and NECA 101 for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies and number of floors.

C. Do not install raceways or electrical items on any "explosion-relief" walls or rotating equipment.

D. Do not fasten conduits onto the bottom side of a metal deck roof.

E. Keep raceways at least 6 inches (150 mm) away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.

F. Complete raceway installation before starting conductor installation.

G. Arrange stub-ups so curved portions of bends are not visible above finished slab.

H. Install no more than the equivalent of three 90-degree bends in any conduit run except for control wiring conduits, for which fewer bends are allowed. Support within 12 inches (300 mm) of changes in direction.

I. Make bends in raceway using large-radius preformed ells. Field bending shall be according to NFPA 70 minimum radii requirements. Use only equipment specifically designed for material and size involved.

J. Conceal conduit within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.

K. Support conduit within 12 inches (300 mm) of enclosures to which attached.

L. Raceways shall not be embedded in slabs:
   1. No conduits shall be run in concrete slab unless specifically indicated on the electrical drawings.
   2. Aluminum conduit is not permitted to be embedded in concrete slabs.
   3. When conduits are allowed embedded in concrete slabs the following apply:
      a. Conduits in concrete slabs must be spaced such that the distance between conduits, centerline to centerline, is a minimum of three times the outside diameter of the largest conduit.
      b. No conduit may be placed in the concrete slab which has an outside diameter larger than one-third the total slab thickness.
      c. Conduit shall be placed in the middle one-third of the slab thickness.
      d. Conduits which cross one another in the concrete slab shall not consume a total space at the point of crossover that is greater than one-third the total slab thickness.
      e. Conduit embedded in slabs shall not pass through cages.
   4. When conduit is to be placed in the slab, the Contractor must advise the Structural Engineer of the number of conduits to be placed and indicate proposed method of installation for the conduits. No conduit shall be placed without the Structural Engineer’s approval.

M. Stub-ups to Above Recessed Ceilings:
   1. Use EMT or RMC for raceways.
   2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.

N. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.

O. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits up to 1-1/4-inch (35mm) trade size and insulated throat metal bushings on 1-1/2-inch (41-mm) trade size and larger conduits terminated with locknuts. Install insulated throat metal grounding bushings on service conduits.

P. Install raceways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.

Q. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to assure a continuous ground path.

R. Cut conduit perpendicular to the length. For conduits 2-inch (53-mm) trade size and larger, use roll cutter or a guide to make cut straight and perpendicular to the length.

S. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb (90-kg) tensile strength. Leave at least 12 inches (300 mm) of slack at each end of pull wire. Cap underground raceways designated as spare above grade alongside raceways in use.

T. Install raceway sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings according to NFPA 70.

U. Install devices to seal raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all raceways at the following points:
   1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
   2. Where an underground service raceway enters a building or structure.
   3. Conduit extending from interior to exterior of building.
   4. Where otherwise required by NFPA 70.

V. Comply with manufacturer's written instructions for solvent welding RNC and fittings.

W. Expansion-Joint Fittings:
   1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F (17 deg C) and that has straight-run length that exceeds 25 feet (7.6 m). Install in each run of aboveground RMC and EMT conduit that is located where environmental temperature change may exceed 100 deg F (55 deg C) and that has straight-run length that exceeds 100 feet (30 m).
   2. Install type and quantity of fittings that accommodate temperature change listed for each of the following locations:
      a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F (70 deg C) temperature change.
      b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F (86 deg C) temperature change.
      c. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F (70 deg C) temperature change.
      d. Attics: 135 deg F (75 deg C) temperature change.

3. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F (0.06 mm per meter of length of straight run per deg C) of temperature change for PVC conduits. Install fitting(s) that provide expansion and contraction for at least 0.000078 inch per foot of length of straight run per deg F (0.0115 mm per meter of length of straight run per deg C) of temperature change for metal conduits.
4. Install expansion fittings at all locations where conduits cross building or structure expansion joints.
5. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.

X. Flexible Conduit Connections: Comply with NEMA RV 3. Use a maximum of 72 inches (1830 mm) of flexible conduit for recessed and semirecessed luminaires, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.
    1. Use LFMC or LFNC in damp or wet locations not subject to severe physical damage.

Y. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to center of box unless otherwise indicated.

Z. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall. Prepare block surfaces to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box.

AA. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.

BB. Locate boxes so that cover or plate will not span different building finishes.

CC. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.

DD. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.

EE. Set metal floor boxes level and flush with finished floor surface.

FF. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.

3.3 FIRESTOPPING

A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.4 PROTECTION

A. Protect coatings, finishes, and cabinets from damage and deterioration.
    1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.

END OF SECTION

SECTION 260553 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Color and legend requirements for raceways, conductors, and warning labels and signs.
   2. Labels.
   3. Bands and tubes.
   4. Tapes and stencils.
   5. Tags.
   6. Signs.
   7. Cable ties.
   8. Paint for identification.
   9. Fasteners for labels and signs.

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 electrical identification products.

B. Identification Schedule: For each piece of electrical equipment and electrical system components to be an index of nomenclature for electrical equipment and system components used in identification signs and labels. Use same designations indicated on Drawings.

C. Delegated-Design Submittal: For arc-flash hazard analysis.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Comply with ASME A13.1.

B. Comply with NFPA 70, “National Electrical Code.”

C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.

D. Comply with ANSI Z535.4 for safety signs and labels.

E. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

F. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.
   1. Temperature Change: 120 deg F (49 deg C), ambient; 180 deg F (82 deg C), material surfaces.

2.2 COLOR AND LEGEND REQUIREMENTS

A. Raceways and Cables Carrying Circuits at 600 V or Less:
   1. Black letters on an orange field.
   2. Legend: Indicate voltage.

B. Color-Coding for Phase- and Voltage-Level Identification, 600 V or Less: Use colors listed below for ungrounded service feeder and branch-circuit conductors.
   1. Color shall be factory applied or field applied for sizes larger than No. 8 AWG if authorities having jurisdiction permit.
   2. Colors for 208/120-V Circuits:
      a. Phase A: Black.
      b. Phase B: Red.
      c. Phase C: Blue.
   3. Color for Neutral: White or gray.
   4. Color for Equipment Grounds: Green.
   5. Colors for Isolated Grounds: Green with white stripe.

C. Raceways and Cables Carrying Circuits at More Than 600 V:
   1. Black letters on an orange field.
   2. Legend: "DANGER - CONCEALED HIGH VOLTAGE WIRING."

D. Warning Label Colors:
   1. Identify system voltage with black letters on an orange background.

E. Warning labels and signs shall include, but are not limited to, the following legends:
   1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
   2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES (915 MM)."

F. Equipment Identification Labels:
   1. Black letters on a white field.

2.3 LABELS

A. Vinyl Wraparound Labels: Preprinted, flexible labels laminated with a clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing label ends.

B. Snap-around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeves, with diameters sized to suit diameters and that stay in place by gripping action.

C. Self-Adhesive Wraparound Labels: Preprinted, 3-mil- (0.08-mm-) thick, polyester flexible label with acrylic pressure-sensitive adhesive.

1. Self-Lamination: Clear; UV-, weather- and chemical-resistant; self-laminating, protective shield over the legend. Labels sized such that the clear shield overlaps the entire printed legend.
2. Marker for Labels: Machine-printed, permanent, waterproof, black ink recommended by printer manufacturer.

D. Self-Adhesive Labels: Polyester, thermal, transfer-printed, 3-mil- (0.08-mm-) thick, multicolor, weather- and UV-resistant, pressure-sensitive adhesive labels, configured for intended use and location.
   1. Minimum Nominal Size:
      a. 1-1/2 by 6 inches (37 by 150 mm) for raceway and conductors.
      b. 3-1/2 by 5 inches (76 by 127 mm) for equipment.
      c. As required by authorities having jurisdiction.

2.4 BANDS AND TUBES

A. Snap-around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeves, 2 inches (50 mm) long, with diameters sized to suit diameters and that stay in place by gripping action.

B. Heat-Shrink Preprinted Tubes: Flame-retardant polyolefin tubes with machine-printed identification labels, sized to suit diameter and shrunk to fit firmly. Full shrink recovery occurs at a maximum of 200 deg F (93 deg C). Comply with UL 224.

2.5 TAPES AND STENCILS

A. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.

B. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; not less than 3 mils (0.08 mm) thick by 1 to 2 inches (25 to 50 mm) wide; compounded for outdoor use.

C. Tape and Stencil: 4-inch- (100-mm-) wide black stripes on 10-inch (250-mm) centers placed diagonally over orange background and is 12 inches (300 mm) wide. Stop stripes at legends.

D. Floor Marking Tape: 2-inch- (50-mm-) wide, 5-mil (0.125-mm) pressure-sensitive vinyl tape, with yellow and black stripes and clear vinyl overlay.

E. Stenciled Legend: In nonfading, waterproof, black ink or paint. Minimum letter height shall be 1 inch (25 mm).

2.6 TAGS

A. Metal Tags: Brass or aluminum, 2 by 2 by 0.05 inch (50 by 50 by 1.3 mm), with stamped legend, punched for use with self-locking cable tie fastener.

B. Nonmetallic Preprinted Tags: Polyethylene tags, 0.015 inch (0.38 mm) thick, color-coded for phase and voltage level, with factory screened permanent designations; punched for use with self-locking cable tie fastener.

C. Write-on Tags:

1. Polyester Tags: 0.010 inch (0.25 mm) thick, with corrosion-resistant grommet and cable tie for attachment.
2. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

2.7 SIGNS

A. Baked-Enamel Signs:
   1. Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application.
   2. 1/4-inch (6.4-mm) grommets in corners for mounting.
   3. Nominal Size: 7 by 10 inches (180 by 250 mm).

B. Metal-Backed Butyrate Signs:
   1. Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs, with 0.0396-inch (1-mm) galvanized-steel backing, punched and drilled for fasteners, and with colors, legend, and size required for application.
   2. 1/4-inch (6.4-mm) grommets in corners for mounting.
   3. Nominal Size: 10 by 14 inches (250 by 360 mm).

C. Laminated Acrylic or Melamine Plastic Signs:
   1. Engraved legend.
   2. Thickness:
      a. For signs up to 20 sq. in. (129 sq. cm), minimum 1/16 inch (1.6 mm) thick).
      b. For signs larger than 20 sq. in. (129 sq. cm), 1/8 inch (3.2 mm) thick.
      c. Engraved legend with black letters on white face.
      d. Punched or drilled for mechanical fasteners with 1/4-inch (6.4-mm) grommets in corners for mounting.
      e. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

2.8 CABLE TIES

A. General-Purpose Cable Ties: Fungus inert, self-extinguishing, one piece, self-locking, and Type 6/6 nylon.
   1. Minimum Width: 3/16 inch (5 mm).
   2. Tensile Strength at 73 Deg F (23 Deg C) according to ASTM D 638: 12,000 psi (82.7 MPa).
   3. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).
   4. Color: Black, except where used for color-coding.

B. UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self-extinguishing, one piece, self-locking, and Type 6/6 nylon.
   1. Minimum Width: 3/16 inch (5 mm).
   2. Tensile Strength at 73 Deg F (23 Deg C) according to ASTM D 638: 12,000 psi (82.7 MPa).
   3. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).
   4. Color: Black.

2.9 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Paint: Comply with requirements in painting Sections for paint materials and application requirements. Retain paint system applicable for surface material and location (exterior or interior).

B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 PREPARATION

A. Self-Adhesive Identification Products: Before applying electrical identification products, clean substrates of substances that could impair bond, using materials and methods recommended by manufacturer of identification product.

3.2 INSTALLATION

A. Verify and coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and operation and maintenance manual. Use consistent designations throughout Project.

B. Install identifying devices before installing acoustical ceilings and similar concealment.

C. Verify identity of each item before installing identification products.

D. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.

E. Apply identification devices to surfaces that require finish after completing finish work.

F. Install signs with approved legend to facilitate proper identification, operation, and maintenance of electrical systems and connected items.

G. System Identification for Raceways and Cables under 600 V: Identification shall completely encircle cable or conduit. Place identification of two-color markings in contact, side by side.
   1. Secure tight to surface of conductor, cable, or raceway.

H. System Identification for Raceways and Cables over 600 V: Identification shall completely encircle cable or conduit. Place adjacent identification of two-color markings in contact, side by side.
   1. Secure tight to surface of conductor, cable, or raceway.

I. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.

J. Elevated Components: Increase sizes of labels, signs, and letters to those appropriate for viewing from the floor.

K. Accessible Fittings for Raceways: Identify the covers of each junction and pull box of the following systems with the wiring system legend and system voltage. System legends shall be as follows:
   1. "POWER."

L. Vinyl Wraparound Labels:
   1. Secure tight to surface of raceway or cable at a location with high visibility and accessibility.
   2. Attach labels that are not self-adhesive type with clear vinyl tape, with adhesive appropriate to the location and substrate.

M. Snap-around Labels: Secure tight to surface at a location with high visibility and accessibility.

N. Self-Adhesive Wraparound Labels: Secure tight to surface at a location with high visibility and accessibility.

O. Self-Adhesive Labels:
   1. On each item, install unique designation label that is consistent with wiring diagrams, schedules, and operation and maintenance manual.
   2. Unless otherwise indicated, provide a single line of text with 1/2-inch- (13-mm-) high letters on 1-1/2-inch- (38-mm-) high label; where two lines of text are required, use labels 2 inches (50 mm) high.

P. Snap-around Color-Coding Bands: Secure tight to surface at a location with high visibility and accessibility.

Q. Heat-Shrink, Preprinted Tubes: Secure tight to surface at a location with high visibility and accessibility.

R. Marker Tapes: Secure tight to surface at a location with high visibility and accessibility.
   1. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches (150 mm) where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding.

S. Tape and Stencil: Comply with requirements in painting Sections for surface preparation and paint application.

T. Floor Marking Tape: Apply stripes to finished surfaces following manufacturer's written instructions.

U. Metal Tags:
   1. Place in a location with high visibility and accessibility.
   2. Secure using general-purpose cable ties.

V. Nonmetallic Preprinted Tags:
   1. Place in a location with high visibility and accessibility.
   2. Secure using general-purpose cable ties.

W. Write-on Tags:
   1. Place in a location with high visibility and accessibility.
   2. Secure using general-purpose cable ties.

X. Baked-Enamel Signs:
1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
2. Unless otherwise indicated, provide a single line of text with 1/2-inch- (13-mm-) high letters on minimum 1-1/2-inch- (38-mm-) high sign; where two lines of text are required, use signs minimum 2 inches (50 mm) high.

Y. Metal-Backed Butyrate Signs:
1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
2. Unless otherwise indicated, provide a single line of text with 1/2-inch- (13-mm-) high letters on 1-1/2-inch- (38-mm-) high sign; where two lines of text are required, use labels 2 inches (50 mm) high.

Z. Laminated Acrylic or Melamine Plastic Signs:
1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
2. Unless otherwise indicated, provide a single line of text with 1/2-inch- (13-mm-) high letters on 1-1/2-inch- (38-mm-) high sign; where two lines of text are required, use labels 2 inches (50 mm) high.

AA. Cable Ties: General purpose, for attaching tags, except as listed below:
1. Outdoors: UV-stabilized nylon.
2. In Spaces Handling Environmental Air: Plenum rated.

3.3 IDENTIFICATION SCHEDULE

A. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment. Install access doors or panels to provide view of identifying devices.

B. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, pull points, and locations of high visibility. Identify by system and circuit designation.

C. Concealed Raceways, Duct Banks, More Than 600 V, within Buildings: Tape and stencil. Stencil legend "DANGER - CONCEALED HIGH-VOLTAGE WIRING" with 3-inch- (75-mm-) high, black letters on 20-inch (500-mm) centers.
1. Locate identification at changes in direction, at penetrations of walls and floors, and at 30-foot (10-m) maximum intervals.

D. Accessible Raceways, 600 V or Less, for Service, Feeder, and Branch Circuits, More Than 30 A and 120 V to Ground: Identify with self-adhesive raceway labels.
1. Locate identification at changes in direction, at penetrations of walls and floors, at 50-foot (15-m) maximum intervals in straight runs, and at 25-foot (7.6-m) maximum intervals in congested areas.

E. Accessible Fittings for Raceways within Buildings: Identify the covers of each junction and pull box of the following systems with self-adhesive labels containing the wiring system legend and system voltage. System legends shall be as follows:
1. "EMERGENCY POWER."
2. "POWER."

F. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, manholes, and handholes, use vinyl wraparound labels to identify the phase.
   1. Locate identification at changes in direction, at penetrations of walls and floors, at 50-foot (15-m) maximum intervals in straight runs, and at 25-foot (7.6-m) maximum intervals in congested areas.

G. Power-Circuit Conductor Identification, More Than 600 V: For conductors in vaults, pull and junction boxes, manholes, and handholes, use nonmetallic preprinted tags colored and marked to indicate phase, and a separate tag with the circuit designation.

H. Control-Circuit Conductor Identification: For conductors and cables in pull and junction boxes, manholes, and handholes, use write-on tags with the conductor or cable designation, origin, and destination.

I. Control-Circuit Conductor Termination Identification: For identification at terminations, provide heat-shrink preprinted tubes with the conductor designation.

J. Conductors to Be Extended in the Future: Attach write-on tags to conductors and list source.

K. Auxiliary Electrical Systems Conductor Identification: Marker tape that is uniform and consistent with system used by manufacturer for factory-installed connections.
   1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.

L. Workspace Indication: Apply floor marking tape to finished surfaces. Show working clearances in the direction of access to live parts. Workspace shall comply with NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.

M. Instructional Signs: Self-adhesive labels, including the color code for grounded and ungrounded conductors.

N. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Baked-enamel warning signs.
   1. Apply to exterior of door, cover, or other access.
   2. For equipment with multiple power or control sources, apply to door or cover of equipment, including, but not limited to, the following:
      a. Power-transfer switches.
      b. Controls with external control power connections.

O. Arc Flash Warning Labeling: Self-adhesive labels.

P. Operating Instruction Signs: Baked-enamel warning signs.

Q. Equipment Identification Labels:
   1. Indoor Equipment: Laminated acrylic or melamine plastic sign.
   2. Outdoor Equipment: Laminated acrylic or melamine sign.
   3. Equipment to Be Labeled:
      a. Panelboards: Typewritten directory of circuits in the location provided by panelboard manufacturer. Panelboard identification shall be in the form of a engraved, laminated acrylic or melamine label.

b. Enclosures and electrical cabinets.
c. Access doors and panels for concealed electrical items.
d. Enclosed switches.
e. Enclosed controllers.
f. Monitoring and control equipment.

END OF SECTION

SECTION 262726 - WIRING DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Straight-blade convenience and tamper-resistant receptacles.
   2. GFCI receptacles.
   3. Toggle switches.
   4. Wall switch sensor light switches with dual technology sensors.
   5. Wall plates.
   6. Floor service outlets.

1.3 DEFINITIONS

A. Abbreviations of Manufacturers' Names:
   1. Eaton (Arrow Hart).
   2. Hubbell: Hubbell Incorporated: Wiring Devices-Kellems.
   3. Leviton: Leviton Mfg. Company, Inc.
   4. Pass & Seymour: Pass& Seymour/Legrand.

B. BAS: Building automation system.

C. EMI: Electromagnetic interference.

D. GFCI: Ground-fault circuit interrupter.

E. Pigtail: Short lead used to connect a device to a branch-circuit conductor.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.

1.5 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing-label warnings and instruction manuals that include labeling conditions.

PART 2 - PRODUCTS

2.1 GENERAL WIRING-DEVICE REQUIREMENTS

A. Wiring Devices, Components, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with NFPA 70, “National Electrical Code.”

C. Devices that are manufactured for use with modular plug-in connectors may be substituted under the following conditions:
   1. Connectors shall comply with UL 2459 and shall be made with stranding building wire.
   2. Devices shall comply with the requirements in this Section.

D. Devices for Owner-Furnished Equipment:
   1. Receptacles: Match plug configurations.
   2. Cord and Plug Sets: Match equipment requirements.

E. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

2.2 STRAIGHT-BLADE RECEPTACLES

A. Duplex Convenience Receptacles: 125 V, 20 A; comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, and FS W-C-596.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Eaton (Arrow Hart).
      b. Hubbell.
      c. Leviton.
      d. Pass & Seymour.

2.3 GFCI RECEPTACLES

A. General Description:
   1. 125 V, 20 A, straight blade, wired as non-feed-through type.
   2. Comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, UL 943 Class A, and FS W-C-596.
   3. Include indicator light that shows when the GFCI has malfunctioned and no longer provides proper GFCI protection.

B. Duplex GFCI Convenience Receptacles:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Eaton (Arrow Hart).
b. Hubbell.
c. Leviton.
d. Pass & Seymour.

2.4 TOGGLE SWITCHES

A. Comply with NEMA WD 1, UL 20, and FS W-S-896.

B. Switches, 120/277 V, 20 A:
1. Single Pole:
a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1) Eaton (Arrow Hart).
2) Hubbell.
3) Leviton.
4) Pass & Seymour.

2.5 WALL SWITCH SENSOR LIGHT SWITCH, DUAL TECHNOLOGY

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Eaton (Arrow Hart).
2. Hubbell.
3. Leviton.
4. Pass & Seymour.

B. Description: Switchbox-mounted, combination lighting-control sensor and conventional switch lighting-control unit using dual technology.
1. Connections: Provisions for connection to BAS.
2. Connections: Hard wired.
3. Connections: Wireless.
4. Rated 960 W at 120-V ac for tungsten lighting, 10 A at 120-V ac or 10 A at 277-V ac for fluorescent or LED lighting, and 1/4 hp at 120-V ac.
5. Integral relay for connection to BAS.
6. Adjustable time delay of 20 minutes.
7. Able to be locked to Automatic-On mode.
8. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc (21.5 to 2152 lux).
9. Comply with NEMA WD 1, UL 20, and FS W-S-896.

2.6 WALL-BOX DIMMERS

A. Dimmer Switches: Modular, full-wave, solid-state units with integral, quiet on-off switches, with audible frequency and EMI/RFI suppression filters.

B. Control: Continuously adjustable slider; with single-pole or three-way switching. Comply with UL 1472.

C. LED Lamp Dimmer Switches: Modular; compatible with LED lamps; trim potentiometer to adjust low-end dimming; capable of consistent dimming with low end not greater than 20 percent of full brightness.

2.7 WALL PLATES

A. Single and combination types shall match corresponding wiring devices.
1. Plate-Securing Screws: Metal with head color to match plate finish.
2. Material for Finished Spaces: 0.035-inch- (1-mm-) thick, satin-finished, Type 302 stainless steel.
3. Material for Unfinished Spaces: Galvanized steel.
4. Material for Damp Locations: Cast aluminum with spring-loaded lift cover, and listed and labeled for use in wet and damp locations.

B. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with Type 3R, weather-resistant, die-cast aluminum with lockable in use cover.

2.8 FLOOR BOXES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. FSR, Inc.
2. Hubbell Incorporated.
3. Wiremold / Legrand.

B. Power & Data Floor Boxes:
1. Model: RFB4-SS, as manufactured by Wiremold Legrand.
2. Material: Stamped steel, for use in concrete floors.
3. Cover, for finished carpeted floors: Architect to select finish.
4. Type: Fully adjustable, UL scrub-water compliant.
5. Provide concrete pour pan for installation of floor boxes at grade. Set pan below floor box prior to concrete pour to allow concrete to flow around and under the box to prevent floor box from contacting the grade.
6. Shape: Rectangular.
7. Power and Data application:
   a. Provide duplex receptacle and conduit connection as noted on drawings.
   b. Provide data conduit connections.
   c. Provide barrier between power and communications devices.
8. Listing and Labeling: Metal floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.9 FINISHES

A. Device Color:
1. Wiring Devices Connected to Normal Power System: White unless otherwise indicated or required by NFPA 70 or device listing.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1, including mounting heights listed in that standard, unless otherwise indicated.

B. Coordination with Other Trades:
   1. Protect installed devices and their boxes. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of boxes.
   2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
   3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
   4. Install wiring devices after all wall preparation, including painting, is complete.

C. Conductors:
   1. Do not strip insulation from conductors until right before they are spliced or terminated on devices.
   2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
   3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
   4. Existing Conductors:
      a. Cut back and pigtail, or replace all damaged conductors.
      b. Straighten conductors that remain and remove corrosion and foreign matter.
      c. Pigtailing existing conductors is permitted, provided the outlet box is large enough.

D. Device Installation:
   1. Replace devices that have been in temporary use during construction and that were installed before building finishing operations were complete.
   2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
   3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
   4. Connect devices to branch circuits using pigtails that are not less than 6 inches (152 mm) in length.
   5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, two-thirds to three-fourths of the way around terminal screw.
   6. Use a torque screwdriver when a torque is recommended or required by manufacturer.
   7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
   8. Tighten unused terminal screws on the device.
   9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device-mounting screws in yokes, allowing metal-to-metal contact.

E. Receptacle Orientation:
   1. Install ground pin of vertically mounted receptacles up, and on horizontally mounted receptacles to the right.

F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

G. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.

H. Adjust locations of floor service outlets to suit arrangement of partitions and furnishings.

3.2 IDENTIFICATION

A. Comply with Section 260553 "Identification for Electrical Systems."

B. Identify each receptacle with panelboard identification and circuit number. Use hot, stamped, or engraved machine printing with black-filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.

3.3 FIELD QUALITY CONTROL

A. Test Instruments: Use instruments that comply with UL 1436.

B. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.

C. Perform the following tests and inspections:
   1. Test Instruments: Use instruments that comply with UL 1436.
   2. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.

D. Tests for Convenience Receptacles:
   1. Line Voltage: Acceptable range is 105 to 132 V.
   2. Ground Impedance: Values of up to 2 ohms are acceptable.
   3. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
   4. Using the test plug, verify that the device and its outlet box are securely mounted.
   5. Tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.

E. Wiring device will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

END OF SECTION

SECTION 262816 - ENCLOSED SWITCHES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Nonfusible switches.
   2. Enclosures.

1.3 DEFINITIONS

A. NC: Normally closed.

B. NO: Normally open.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include nameplate ratings, dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.
   1. Enclosure types and details for types other than NEMA 250, Type 1.
   2. Current and voltage ratings.
   3. Short-circuit current ratings (interrupting and withstand, as appropriate).
   4. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.

B. Shop Drawings: For enclosed switches and circuit breakers.
   1. Include plans, elevations, sections, details, and attachments to other work.
   2. Include wiring diagrams for power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified testing agency.

B. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals.
   1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.
b. Time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device. Provide in PDF electronic format.

1.7 QUALITY ASSURANCE

A. Testing Agency Qualifications: Accredited by NETA.
1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

1.8 FIELD CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:
1. Ambient Temperature: Not less than minus 22 deg F (minus 30 deg C) and not exceeding 104 deg F (40 deg C).
2. Altitude: Not exceeding 6600 feet (2010 m).

1.9 WARRANTY

A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace components that fail in materials or workmanship within specified warranty period.
1. Warranty Period: One year(s) from date of Substantial Completion.
2.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

C. Comply with NFPA 70, “National Electrical Code.”

2.2 NONFUSIBLE SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Eaton.
2. General Electric Company.
3. Siemens Industry, Inc.
4. Schneider Electric; Square D.

B. Type HD, Heavy Duty, Three Pole, Single Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

C. Accessories:
1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Lugs: Mechanical type, suitable for number, size, and conductor material.
4. Auxiliary Contact Kit: One NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open. Contact rating - 24-V ac

2.3 ENCLOSURES

A. Enclosed Switches: UL 489, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.

B. Enclosure Finish: The enclosure shall be finished with gray baked enamel paint, electrodeposited on cleaned, phosphatized steel (NEMA 250 Type 1) and gray baked enamel paint, electrodeposited on cleaned, phosphatized galvannealed steel (NEMA 250 Types 3R, 12).

C. Conduit Entry: NEMA 250 Types 4, 4X, and 12 enclosures shall contain no knockouts. Enclosures designated as NEMA 250 Type 4, 4X stainless steel, 12, or 12K shall have a dual cover interlock mechanism to prevent unintentional opening of the enclosure cover when the switch is ON and to prevent turning the circuit breaker ON when the enclosure cover is open.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine elements and surfaces to receive enclosed switches for compliance with installation tolerances and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.
1. Commencement of work shall indicate Installer's acceptance of the areas and conditions as satisfactory.

3.2 PREPARATION

A. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
1. Notify Owner no fewer than seven days in advance of proposed interruption of electric service.
2. Indicate method of providing temporary electric service.
3. Do not proceed with interruption of electric service without Owner's written permission.
4. Comply with NFPA 70E, “Standard for Electrical Safety in the Workplace.”

3.3 ENCLOSURE ENVIRONMENTAL RATING APPLICATIONS

A. Enclosed Switches: Provide enclosures at installed locations with the following environmental ratings.
   1. Indoor, Dry and Clean Locations: NEMA 250, Type 1.
   2. Outdoor Locations: NEMA 250, Type 3R.
   3. Other Wet or Damp, Indoor Locations: NEMA 250, Type 4 .
   4. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.

3.4 INSTALLATION

A. Coordinate layout and installation of switches, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.

C. Temporary Lifting Provisions: Remove temporary lifting of eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

D. Install fuses in fusible devices.

E. Comply with NFPA 70 and NECA 1.

3.5 IDENTIFICATION

A. Comply with requirements in Section 260553 "Identification for Electrical Systems."
   1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
   2. Label each enclosure with engraved metal or laminated-plastic nameplate.

3.6 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Tests and Inspections for Switches:
   1. Visual and Mechanical Inspection:
      a. Inspect physical and mechanical condition.
      b. Inspect anchorage, alignment, grounding, and clearances.
      c. Verify that the unit is clean.
      d. Verify blade alignment, blade penetration, travel stops, and mechanical operation.
      e. Inspect bolted electrical connections for high resistance using one of the two following methods:
         1) Use a low-resistance ohmmeter.
            a) Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.

2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.
   a) Bolt-torque levels shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.

f. Verify that operation and sequencing of interlocking systems is as described in the Specifications and shown on the Drawings.
g. Verify correct phase barrier installation.
h. Verify lubrication of moving current-carrying parts and moving and sliding surfaces.

2. Electrical Tests:
   a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter. Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
   b. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with switch closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.1 from the NETA ATS. Investigate values of insulation resistance less than those published in Table 100.1 or as recommended in manufacturer's published data.
   c. Perform ground fault test according to NETA ATS 7.14 "Ground Fault Protection Systems, Low-Voltage."

D. Enclosed switches and will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.
   1. Test procedures used.
   2. Include identification of each enclosed switch tested and describe test results.
   3. List deficiencies detected, remedial action taken, and observations after remedial action.

3.7 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

END OF SECTION

SECTION 262913.03 - MANUAL AND MAGNETIC MOTOR 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. Section Includes:
   1. Manual motor controllers.
   2. Enclosures.
   3. Accessories.
   4. Identification.

1.3 DEFINITIONS

A. CPT: Control power transformer.

B. MCCB: Molded-case circuit breaker.

C. MCP: Motor circuit protector.

D. NC: Normally closed.

E. OCPD: Overcurrent protective device.

F. SCCR: Short-circuit current rating.

G. SCPD: Short-circuit protective device.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For each type of magnetic controller.
   1. Include plans, elevations, sections, and mounting details.
   2. Indicate dimensions, weights, required clearances, and location and size of each field connection.
   3. Wire Termination Diagrams and Schedules: Include diagrams for signal, and control wiring. Identify terminals and wiring designations and color-codes to facilitate installation, operation, and maintenance. Indicate recommended types, wire sizes, and circuiting arrangements for field-installed wiring, and show circuit protection features. Differentiate between manufacturer-installed and field-installed wiring.

4. Include features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

C. Product Schedule: List the following for each enclosed controller:
   1. Each installed magnetic controller type.
   2. NRTL listing.
   3. Factory-installed accessories.
   4. Nameplate legends.
   5. SCCR of integrated unit.
   6. For each combination magnetic controller include features, characteristics, ratings, and factory setting of the SCPD and OCPD.
      a. Listing document proving Type 2 coordination.
   7. For each series-rated combination state the listed integrated short-circuit current (withstand) rating of SCPD and OCPDs by an NRTL acceptable to authorities having jurisdiction.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For magnetic controllers to include in operation and maintenance manuals.
   1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
      a. Routine maintenance requirements for magnetic controllers and installed components.
      b. Manufacturer's written instructions for testing and adjusting circuit breaker and MCP trip settings.
      c. Manufacturer's written instructions for setting field-adjustable overload relays.

1.7 QUALITY ASSURANCE

A. Testing Agency Qualifications: Accredited by NETA.
   1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Store controllers indoors in clean, dry space with uniform temperature to prevent condensation. Protect controllers from exposure to dirt, fumes, water, corrosive substances, and physical damage.

B. If stored in areas subject to weather, cover controllers to protect them from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside controllers; install temporary electric heating, with at least 50 W per controller.

1.9 FIELD CONDITIONS

A. Ambient Environment Ratings: Rate equipment for continuous operation under the following conditions unless otherwise indicated:
   1. Ambient Temperature: Not less than 23 deg F (minus 5 deg C) and not exceeding 104 deg F (40 deg C).
   2. Altitude: Not exceeding 6600 feet (2010 m) for electromagnetic and manual devices.
   3. The effect of solar radiation is not significant.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

B. UL Compliance: Fabricate and label magnetic motor controllers to comply with UL 508 and UL 60947-4-1.

C. NEMA Compliance: Fabricate motor controllers to comply with ICS 2.

2.2 MANUAL MOTOR CONTROLLERS

A. Motor-Starting Switches (MSS): "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off or on.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Eaton.
      b. General Electric Company.
      c. Siemens Industry, Inc.
      d. Square D; a brand of Schneider Electric.
   2. Standard: Comply with NEMA ICS 2, general purpose, Class A.
   3. Configuration: Nonreversing.
   4. Surface mounting.
   5. Red pilot light.

B. Fractional Horsepower Manual Controllers (FHPMC): "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off, on, or tripped.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Eaton.
      b. General Electric Company.
      c. Siemens Industry, Inc.
      d. Square D; a brand of Schneider Electric.
   2. Configuration: Nonreversing.
   3. Overload Relays: Inverse-time-current characteristics; NEMA ICS 2, Class 10 tripping characteristics; heaters matched to nameplate full-load current of actual protected motor; external reset push button; bimetallic type.
   4. Pilot Light: Red.

C. Integral Horsepower Manual Controllers (IHPMC): "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off, on, or tripped.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Eaton.
      b. General Electric Company.
      c. Siemens Industry, Inc.
      d. Square D; a brand of Schneider Electric.
   2. Configuration: Nonreversing.
   3. Overload Relays: Inverse-time-current characteristics; NEMA ICS 2, Class 10 tripping characteristics; heaters matched to nameplate full-load current of actual protected motor; external reset push button; bimetallic type.
   4. Overload Relays: NEMA ICS 2, bimetallic class as scheduled on Drawings.

2.3 ENCLOSURES

A. Comply with NEMA 250, type designations as indicated on Drawings, complying with environmental conditions at installed location.

B. The construction of the enclosures shall comply with NEMA ICS 6.

C. Controllers in hazardous (classified) locations shall comply with UL 1203.

2.4 ACCESSORIES

A. General Requirements for Control Circuit and Pilot Devices: NEMA ICS 5; factory installed in controller enclosure cover unless otherwise indicated.
   1. Push Buttons, Pilot Lights, and Selector Switches: Standard-duty, except as needed to match enclosure type. Heavy-duty or oil-tight where indicated in the controller schedule.
      a. Push Buttons: As indicated in the controller schedule.
      b. Pilot Lights: As indicated in the controller schedule.
      c. Selector Switches as indicated in the Controller Schedule.

2.5 IDENTIFICATION

A. Controller Nameplates: Laminated acrylic or melamine plastic signs, as described in Section 260553 "Identification for Electrical Systems," for each compartment, mounted with corrosion-resistant screws.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and space conditions for compliance with requirements for motor controllers, their relationship with the motors, and other conditions affecting performance of the Work.

3.2 INSTALLATION

A. Comply with NECA 1, “Standard Practice for Good Workmanship in Electrical Construction.”

B. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.

C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

D. Setting of Overload Relays: Select and set overloads on the basis of full-load current rating as shown on motor nameplate. Adjust setting value for special motors as required by NFPA 70 for motors that are high-torque, high-efficiency, and so on.

3.3 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Tests and Inspections:
   1. Comply with the provisions of NFPA 70B, "Testing and Test Methods" Chapter.
   2. Visual and Mechanical Inspection:
      a. Compare equipment nameplate data with drawings and specifications.
      b. Inspect physical and mechanical condition.
      c. Inspect anchorage, alignment, and grounding.
      d. Verify the unit is clean.
      e. Inspect contactors:
         1) Verify mechanical operation.
         2) Verify contact gap, wipe, alignment, and pressure are according to manufacturer's published data.
      f. Motor-Running Protection:
         1) Verify overload element rating is correct for its application.
         2) If motor-running protection is provided by fuses, verify correct fuse rating.
      g. Inspect bolted electrical connections for high resistance using one of the two following methods:
         1) Use a low-resistance ohmmeter. Compare bolted connection resistance values with values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
         2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method according to manufacturer's published data or NETA ATS Table 100.12. Bolt-torque levels shall be according to manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.
      h. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
   3. Electrical Tests:
      a. For the contactor and circuit breaker, perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with switch closed, and across each open pole. Insulation-resistance values shall be according to manufacturer's published data or NETA ATS Table 100.1. In the absence of

manufacturer's published data, use Table 100.5. Values of insulation resistance less than those of this table or manufacturer's recommendations shall be investigated and corrected.

b. Measure fuse resistance. Investigate fuse-resistance values that deviate from each other by more than 15 percent.
c. Test motor protection devices according to manufacturer's published data.
d. Perform operational tests by initiating control devices.

C. Motor controller will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.5 SYSTEM FUNCTION TESTS

A. System function tests shall prove the correct interaction of sensing, processing, and action devices. Perform system function tests after field quality control tests have been completed and all components have passed specified tests.

1. Develop test parameters and perform tests for the purpose of evaluating performance of integral components and their functioning as a complete unit within design requirements and manufacturer's published data.
2. Verify the correct operation of interlock safety devices for fail-safe functions in addition to design function.
3. Verify the correct operation of sensing devices, alarms, and indicating devices.

B. Motor controller will be considered defective if it does not pass the system function tests and inspections.

C. Prepare test and inspection reports.

3.6 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain motor controllers.

END OF SECTION

SECTION 262923 - VARIABLE-FREQUENCY MOTOR 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. Section includes separately enclosed, preassembled, combination VFCs, rated 600 V and less, for speed control of three-phase, squirrel-cage induction motors.

1.3 DEFINITIONS

A. CE: Conformite Europeene (European Compliance).

B. CPT: Control power transformer.

C. DDC: Direct digital control.

D. EMI: Electromagnetic interference.

E. LED: Light-emitting diode.

F. NC: Normally closed.

G. NO: Normally open.

H. OCPD: Overcurrent protective device.

I. PID: Control action, proportional plus integral plus derivative.

J. RFI: Radio-frequency interference.

K. VFC: Variable-frequency motor controller.

1.4 ACTION SUBMITTALS

A. Product Data: For each type and rating of VFC indicated.
   1. Include dimensions and finishes for VFCs.
   2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For each VFC indicated.
   1. Include mounting and attachment details.

2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout on which the following items are shown and coordinated with each other, using input from installers of the items involved:
   1. Required working clearances and required area above and around VFCs.
   2. Show VFC layout and relationships between electrical components and adjacent structural and mechanical elements.
   3. Show support locations, type of support, and weight on each support.
   4. Indicate field measurements.

B. Qualification Data: For testing agency.

C. Product Certificates: For each VFC from manufacturer.

D. Harmonic Analysis Report: Provide Project-specific calculations and manufacturer's statement of compliance with IEEE 519.

E. Source quality-control reports.

F. Field quality-control reports.

G. Sample Warranty: For special warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For VFCs 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. Manufacturer's written instructions for testing and adjusting thermal-magnetic circuit breaker trip settings.
      b. Manufacturer's written instructions for setting field-adjustable overload relays.
      c. Manufacturer's written instructions for testing, adjusting, and reprogramming microprocessor control modules.
      d. Manufacturer's written instructions for setting field-adjustable timers, controls, and status and alarm points.
      e. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed, and arrange to demonstrate that switch settings for motor-running overload protection suit actual motors to be protected.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
2. Control Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
3. Indicating Lights: Two of each type and color installed.
4. Auxiliary Contacts: Furnish one spare(s) for each size and type of magnetic controller installed.
5. Power Contacts: Furnish three spares for each size and type of magnetic contactor installed.

1.8 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.
   1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

1.9 DELIVERY, STORAGE, AND HANDLING

A. If stored in space that is not permanently enclosed and air conditioned, remove loose packing and flammable materials from inside controllers and install temporary electric heating, with at least 250 W per controller.

1.10 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace VFCs that fail in materials or workmanship within specified warranty period.
   1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. ABB.
   2. Yaskawa.
   3. Eaton.
   4. Toshiba International Corp.
   5. Schneider Electric USA, Inc.

2.2 SYSTEM DESCRIPTION

A. General Requirements for VFCs:
   1. VFCs and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
   2. Comply with NEMA ICS 7, NEMA ICS 61800-2, and UL 508C.

B. Application: variable torque.

C. VFC Description: Variable-frequency motor controller, consisting of power converter that employs pulse-width-modulated inverter, factory built and tested in an enclosure, with integral disconnecting means and overcurrent and overload protection; listed and labeled by an NRTL as a complete unit; arranged to provide self-protection, protection, and variable-speed control of one or more three-phase induction motors by adjusting output voltage and frequency.
1. Units suitable for operation of NEMA MG 1, Design A and Design B motors, as defined by NEMA MG 1, Section IV, Part 30, "Application Considerations for Constant Speed Motors Used on a Sinusoidal Bus with Harmonic Content and General Purpose Motors Used with Adjustable-Voltage or Adjustable-Frequency Controls or Both."
2. Units suitable for operation of inverter-duty motors as defined by NEMA MG 1, Section IV, Part 31, "Definite-Purpose Inverter-Fed Polyphase Motors."
3. Listed and labeled for integrated short-circuit current (withstand) rating by an NRTL acceptable to authorities having jurisdiction.

D. Design and Rating: Match load type, such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.

E. Output Rating: Three phase; 10 to 60 Hz, with voltage proportional to frequency throughout voltage range; maximum voltage equals input voltage.

F. Unit Operating Requirements:
1. Input AC Voltage Tolerance: Plus 10 and minus 10 percent of VFC input voltage rating.
2. Input AC Voltage Unbalance: Not exceeding 5percent.
3. Input Frequency Tolerance: Plus or minus 3 percent of VFC frequency rating.
4. Minimum Efficiency: 96 percent at 60 Hz, full load.
5. Minimum Displacement Primary-Side Power Factor: 96 percent under any load or speed condition.
6. Minimum Short-Circuit Current (Withstand) Rating: 100 kA.
7. Ambient Temperature Rating: Not less than 32 deg F (0 deg C) and not exceeding 104 deg F (40 deg C).
8. Humidity Rating: Less than 95 percent (noncondensing).
9. Altitude Rating: Not exceeding 3300 feet (1000 m).
10. Vibration Withstand: Comply with NEMA ICS 61800-2.
11. Overload Capability: 1.1 times the base load current for 60 seconds; minimum of 1.8 times the base load current for three seconds.
12. Starting Torque: Minimum 100 percent of rated torque from 3 to 60 Hz.
13. Speed Regulation: Plus or minus 5 percent.
14. Output Carrier Frequency: Selectable; 0.5 to 15 kHz.
15. Stop Modes: Programmable; includes fast, free-wheel, and dc injection braking.

G. Inverter Logic: Microprocessor based, 32 bit, isolated from all power circuits.

H. Isolated Control Interface: Allows VFCs to follow remote-control signal over a minimum 40:1 speed range.
1. Signal: Electrical.

I. Internal Adjustability Capabilities:
1. Minimum Speed: 5 to 25 percent of maximum rpm.
2. Maximum Speed: 80 to 100 percent of maximum rpm.
3. Acceleration: 0.1 to 999.9 seconds.
4. Deceleration: 0.1 to 999.9 seconds.
5. Current Limit: 30 to minimum of 150 percent of maximum rating.

J. Self-Protection and Reliability Features:
1. Surge Suppression: Factory installed as an integral part of the VFC, complying with UL 1449 SPD, Type 1 or Type 2.
2. Loss of Input Signal Protection: Selectable response strategy, including speed default to a percent of the most recent speed, a preset speed, or stop; with alarm.
3. Under- and overvoltage trips.
4. Inverter overcurrent trips.
5. VFC and Motor-Overload/Overtemperature Protection: Microprocessor-based thermal protection system for monitoring VFCs and motor thermal characteristics, and for providing VFC overtemperature and motor-overload alarm and trip; settings selectable via the keypad.
6. Critical frequency rejection, with three selectable, adjustable deadbands.
7. Instantaneous line-to-line and line-to-ground overcurrent trips.
8. Loss-of-phase protection.
9. Reverse-phase protection.
10. Short-circuit protection.
11. Motor-overtemperature fault.
12. Input power fuses dedicated for VFC drive unit.

K. Automatic Reset/Restart: Attempt three restarts after drive fault or on return of power after an interruption and before shutting down for manual reset or fault correction; adjustable delay time between restart attempts.

L. Power-Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped, unless "Bidirectional Autospeed Search" feature is available and engaged.

M. Bidirectional Autospeed Search: Capable of starting VFC into rotating loads spinning in either direction and returning motor to set speed in proper direction, without causing damage to drive, motor, or load.

N. 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.

O. 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.

P. Integral Input Disconnecting Means and OCPD: UL 489, thermal-magnetic circuit breaker with pad-lockable, door-mounted handle mechanism.
1. Disconnect Rating: Not less than 115 percent of VFC input current rating.
2. Disconnect Rating: Not less than 115 percent of NFPA 70 motor full-load current rating or VFC input current rating, whichever is larger.
3. Auxiliary contacts "a" and "b" arranged to activate with circuit-breaker handle.

2.3 CONTROLS AND INDICATION

A. Status Lights: Door-mounted LED indicators displaying the following conditions:
1. Power on.
2. Run.
3. Overvoltage.
4. Line fault.

5. Overcurrent.
6. External fault.

B. Panel-Mounted Operator Station: Manufacturer's standard front-accessible, sealed keypad and plain-English-language digital display; allows complete programming, program copying, operating, monitoring, and diagnostic capability.
  1. Keypad: In addition to required programming and control keys, include keys for HAND, OFF, and AUTO modes.
  2. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: View only; view and operate; and view, operate, and service.
     a. Control Authority: Supports at least four conditions: Off, local manual control at VFC, local automatic control at VFC, and automatic control through a remote source.

C. Historical Logging Information and Displays:
  1. Real-time clock with current time and date.
  2. Running log of total power versus time.
  3. Total run time.
  4. Fault log, maintaining last four faults with time and date stamp for each.

D. Indicating Devices: Digital display and additional readout devices as required, mounted flush in VFC door and connected to display VFC parameters including, but not limited to:
  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 (V dc).
  9. Set point frequency (Hz).
  10. Motor output voltage (V ac).

E. Control Signal Interfaces:
  1. Electric Input Signal Interface:
     a. A minimum of two programmable analog inputs: 0- to 10-V dc 4- to 20-mA dc.
     b. A minimum of six multifunction programmable digital inputs.
  2. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the DDC system for HVAC or other control systems:
     a. 0- to 10-V dc.
     b. 4- to 20-mA dc.
     c. Potentiometer using up/down digital inputs.
     d. Fixed frequencies using digital inputs.
  3. Output Signal Interface: A minimum of one programmable analog output signal(s) (4- to 20-mA dc), which can be configured for any of the following:
     a. Output frequency (Hz).
     b. Output current (load).
     c. DC-link voltage (V dc).
     d. Motor torque (percent).
     e. Motor speed (rpm).
     f. Set point frequency (Hz).

4. Remote Indication Interface: A minimum of two programmable dry-circuit relay outputs (120-V ac, 1 A) for remote indication of the following:
    a. Motor running.
    b. Set point speed reached.
    c. Fault and warning indication (overtemperature or overcurrent).
    d. PID high- or low-speed limits reached.

F. Interface with DDC System for HVAC: Factory-installed hardware and software shall interface with DDC system for HVAC to monitor, control, display, and record data for use in processing reports. VFC settings shall be retained within VFC's nonvolatile memory.
1. Hardwired Points:
    a. Monitoring: On-off status.
    b. Control: On-off operation.
2. Communication Interface: Comply with ASHRAE 135. Communication shall interface with DDC system for HVAC to remotely control and monitor lighting from a DDC system for HVAC operator workstation. Control features and monitoring points displayed locally at lighting panel shall be available through the DDC system for HVAC.

2.4 LINE CONDITIONING AND FILTERING

A. Input Line Conditioning: Based on the manufacturer's harmonic analysis study and report, provide input filtering, as required, to limit total demand (harmonic current) distortion and total harmonic voltage demand at the defined point of common coupling to meet IEEE 519 recommendations. As a minimum, provide a 5 percent input line reactor, integral to the VFC.

B. EMI/RFI Filtering: CE marked; certify compliance with IEC 61800-3 for Category C2.

2.5 OPTIONAL FEATURES

A. Communication Port: RS-232 port, USB 2.0 port, or equivalent connection capable of connecting a printer and a notebook computer.

2.6 ENCLOSURES

A. VFC Enclosures: UL 50 labeled, to comply with environmental conditions at installed location.
1. Dry and Clean Indoor Locations: Type 1.
2. Outdoor Locations: Type 3R.
3. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: Type 12.

2.7 ACCESSORIES

A. General Requirements for Control-Circuit and Pilot Devices: NEMA ICS 5; factory installed in VFC enclosure cover unless otherwise indicated.
1. Push Buttons: Covered.
2. Pilot Lights: Push to test.
3. Selector Switches: Rotary type.

B. Control Relays: Auxiliary and adjustable solid-state time-delay relays.

C. Phase-Failure, Phase-Reversal, and Undervoltage and Overvoltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connections. Provide adjustable undervoltage, overvoltage, and time-delay settings.
   1. Current Transformers: Continuous current rating, basic impulse insulating level (BIL) rating, burden, and accuracy class suitable for connected circuitry. Comply with IEEE C57.13.

D. Cooling Fan and Exhaust System: For UL 50, Type 1; UL 508 component recognized: Supply fan, with composite intake and exhaust grills and filters; 120-V ac; obtained from integral CPT.

2.8 SOURCE QUALITY CONTROL

A. Testing: Test and inspect VFCs according to requirements in NEMA ICS 61800-2.
   1. Test each VFC while connected to its specified motor.
   2. Verification of Performance: Rate VFCs according to operation of functions and features specified.

B. VFCs will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, surfaces, and substrates to receive VFCs, with Installer present, for compliance with requirements for installation tolerances, and other conditions affecting performance of the Work.

B. Examine VFC before installation. Reject VFCs that are wet, moisture damaged, or mold damaged.

C. Examine roughing-in for conduit systems to verify actual locations of conduit connections before VFC installation.

D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work

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

3.2 INSTALLATION

A. Wall-Mounting Controllers: Install with tops at uniform height and with disconnect operating handles not higher than 79 inches (2000 mm) above finished floor, unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not on walls, provide freestanding racks complying with Section 260529 "Hangers and Supports for Electrical Systems."

B. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

C. Install fuses in control circuits if not factory installed. Comply with requirements in Section 262813 "Fuses."

D. Install heaters in thermal-overload relays. Select heaters based on actual nameplate full-load amperes after motors are installed.

E. Comply with NECA 1, “Standard Practice for Good Workmanship in Electrical Construction.”

3.3 CONTROL WIRING INSTALLATION

A. Bundle, train, and support wiring in enclosures.

B. Connect selector switches and other automatic-control devices where applicable.
   1. Connect selector switches to bypass only those manual- and automatic-control devices that have no safety functions when switches are in manual-control position.
   2. Connect selector switches with control circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor-overload protectors.

C. When local disconnect is used at the motor, provide a normally open auxiliary contact in local disconnect wired to the VFC control to stop the VFC when disconnect is “OFF.”

3.4 CONDUIT CONNECTIONS

A. Install all conduits into bottom of VFC enclosure. Input conductors must be in separate conduit from output conductors.

3.5 IDENTIFICATION

A. Identify VFCs, components, and control wiring. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
   1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
   2. Label each VFC with engraved nameplate.
   3. Label each enclosure-mounted control and pilot device.

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. Acceptance Testing Preparation:
   1. Test insulation resistance for each VFC element, bus, component, connecting supply, feeder, and control circuit.
   2. Test continuity of each circuit.

C. Tests and Inspections:
   1. Inspect VFC, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
   2. Test insulation resistance for each VFC element, component, connecting motor supply, feeder, and control circuits.

3. Test continuity of each circuit.
4. Verify that voltages at VFC locations are within 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify Architect before starting the motor(s).
5. Test each motor for proper phase rotation.
6. Perform tests according to the Inspection and Test Procedures for Adjustable Speed Drives stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
7. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
8. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

D. VFCs will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports, including a certified report that identifies the VFC. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

3.7 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.
   1. Complete installation and startup checks according to manufacturer's written instructions.

3.8 ADJUSTING

A. Program microprocessors for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Substantial Completion.

B. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.

C. Adjust the trip settings of thermal-magnetic circuit breakers with adjustable, instantaneous trip elements. Initially adjust to 6 times the motor nameplate full-load amperes and attempt to start motors several times, allowing for motor cool-down between starts. If tripping occurs on motor inrush, adjust settings in increments until motors start without tripping. Do not exceed 8 times the motor full-load amperes (or 11 times for NEMA Premium Efficient motors if required). Where these maximum settings do not allow starting of a motor, notify Architect before increasing settings.

D. Set field-adjustable pressure switches.

3.9 PROTECTION

A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions until controllers are ready to be energized and placed into service.

B. Protect VFCs in operation prior to substantial completion. Areas around VFCs shall be cleaned daily, temporary filter media to be utilized at ventilation air openings, and VFCs to cleaned prior to turnover using manufacturer’s approved methods.

C. Replace VFCs whose interiors have been exposed to water or other liquids prior to Substantial Completion.

3.10 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, reprogram, and maintain VFCs.

END OF SECTION

SECTION 265119 - LED INTERIOR LIGHTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes LED luminaires.

1.3 DEFINITIONS

A. CCT: Correlated color temperature.

B. CRI: Color Rendering Index.

C. Fixture: See "Luminaire."

D. IP: International Protection or Ingress Protection Rating.

E. LED: Light-emitting diode.

F. Lumen: Measured output of lamp and luminaire, or both.

G. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Arrange in order of luminaire designation.
   2. Include data on features, accessories, and finishes.
   3. Include physical description and dimensions of luminaires.
   4. Include life, output (lumens, CCT, and CRI), and energy efficiency data.
   5. Photometric data and adjustment factors based on laboratory tests, complying with IES Lighting Measurements Testing and Calculation Guides, of each luminaire type. The adjustment factors shall be for lamps and accessories identical to those indicated for the luminaire as applied in this Project.
      a. Manufacturers' Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.

B. Shop Drawings: For nonstandard or custom luminaires.
   1. Include plans, elevations, sections, and mounting and attachment details.
   2. Include details of luminaire assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

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

C. Product Schedule: For luminaires and lamps. Use same designations indicated on Drawings.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing laboratory providing photometric data for luminaires.

B. Product Certificates: For each type of luminaire.

C. Product Test Reports: For each luminaire, for tests performed by manufacturer and witnessed by a qualified testing agency.

D. Sample warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For luminaires and lighting systems to include in operation and maintenance manuals.

1.7 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturer's laboratory that is accredited under the NVLAP for Energy Efficient Lighting Products.

B. Provide luminaires from a single manufacturer for each luminaire type.

C. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering before shipping.

1.9 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.

B. Warranty Period: Five year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 LUMINAIRE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Standards:

1. ENERGY STAR certified.
2. UL Listing: Listed for damp location.
3. Recessed luminaires shall comply with NEMA LE 4.
4. User Replaceable Lamps:
   a. Bulb shape complying with ANSI C78.79.
   b. Lamp base complying with ANSI C81.61.

C. CRI of minimum 80 CCT of 3000 K.

D. Rated lamp life of 50,000 hours to L70.

E. Lamps dimmable from 100 percent to 0 percent of maximum light output.

F. Internal driver.

G. Nominal Operating Voltage: 120 V ac.
   1. Lens Thickness: At least 0.125 inch (3.175 mm) minimum unless otherwise indicated.

2.2 MATERIALS

A. Metal Parts:
   1. Free of burrs and sharp corners and edges.
   2. Sheet metal components shall be steel unless otherwise indicated.
   3. Form and support to prevent warping and sagging.

B. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

C. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps. Locate labels where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.
   1. Label shall include the following lamp characteristics:
      a. "USE ONLY" and include specific lamp type.
      b. Lamp diameter, shape, size, wattage, and coating.
      c. CCT and CRI for all luminaires.

2.3 METAL FINISHES

A. Variations in finishes are unacceptable in the same piece. Variations in finishes of adjoining components are acceptable if they are within the range of approved Samples and if they can be and are assembled or installed to minimize contrast.

2.4 LUMINAIRE SUPPORT

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

B. Single-Stem Hangers: 1/2-inch (13-mm) steel tubing with swivel ball fittings and ceiling canopy. Finish same as luminaire.

C. Wires: ASTM A 641/A 641 M, Class 3, soft temper, zinc-coated steel, 12 gage (2.68 mm).

D. Rod Hangers: 3/16-inch (5-mm) minimum diameter, cadmium-plated, threaded steel rod.

E. Hook Hangers: Integrated assembly matched to luminaire, line voltage, and equipment with threaded attachment, cord, and locking-type plug.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for luminaire to verify actual locations of luminaire and electrical connections before luminaire installation. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 TEMPORARY LIGHTING

A. If approved by the Architect, use selected permanent luminaires for temporary lighting. When construction is sufficiently complete, clean luminaires used for temporary lighting and install new lamps.

3.3 INSTALLATION

A. Comply with NECA 1, “Standard Practice for Good Workmanship in Electrical Construction.”

B. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.

C. Install lamps in each luminaire.

D. Supports:
   1. Sized and rated for luminaire weight.
   2. Able to maintain luminaire position after cleaning and relamping.
   3. Provide support for luminaire without causing deflection of ceiling or wall.
   4. Luminaire mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and vertical force of 400 percent of luminaire weight.

E. Flush-Mounted Luminaire Support:
   1. Secured to outlet box.
   2. Attached to ceiling structural members at four points equally spaced around circumference of luminaire.
   3. Trim ring flush with finished surface.

F. Wall-Mounted Luminaire Support:
   1. Attached to structural members in walls.
   2. Do not attach luminaires directly to gypsum board.

G. Ceiling-Mounted Luminaire Support:

1. Ceiling mount with two 5/32-inch- (4-mm-) diameter aircraft cable supports adjustable to 120 inches (6 m) in length.
2. Ceiling mount with pendant mount with 5/32-inch- (4-mm-) diameter aircraft cable supports adjustable to 120 inches (6 m) in length.
3. Ceiling mount with hook mount.

H. Suspended Luminaire Support:
    1. Pendants and Rods: Where longer than 48 inches (1200 mm), brace to limit swinging.
    2. Stem-Mounted, Single-Unit Luminaires: Suspend with twin-stem hangers. Support with approved outlet box and accessories that hold stem and provide damping of luminaire oscillations. Support outlet box vertically to building structure using approved devices.
    3. Continuous Rows of Luminaires: Use tubing or stem for wiring at one point and wire support for suspension for each unit length of luminaire chassis, including one at each end.
    4. Do not use ceiling grid as support for pendant luminaires. Connect support wires or rods to building structure.

I. Ceiling-Grid-Mounted Luminaires:
    1. Secure to any required outlet box.
    2. Use approved devices and support components to connect luminaire to ceiling grid and building structure in a minimum of four locations, spaced near corners of luminaire.

J. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.

3.4 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:
    1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.

B. Luminaire will be considered defective if it does not pass operation tests and inspections.

C. Prepare test and inspection reports.

3.6 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting the direction of aim of luminaires to suit occupied conditions. Make up to two visits to Project during other-than-normal hours for this purpose. Some of this work may be required during hours of darkness.
    1. During adjustment visits, inspect all luminaires. Replace lamps or luminaires that are defective.
    2. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
    3. Adjust the aim of luminaires in the presence of the Architect.

END OF SECTION

SECTION 265219 - EXIT LIGHTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
1. Exit signs.
2. Luminaire supports.

1.3 DEFINITIONS

A. CCT: Correlated color temperature.

B. CRI: Color Rendering Index.

C. Fixture: See "Luminaire" Paragraph.

D. Lumen: Measured output of lamp and luminaire, or both.

E. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of emergency lighting unit, exit sign, and emergency lighting support.
1. Include data on features, accessories, and finishes.
2. Include physical description of the unit and dimensions.
3. Include life, output of luminaire (lumens, CCT, and CRI), and energy-efficiency data.
4. Include photometric data and adjustment factors based on laboratory tests, complying with IES LM-45, for each luminaire type.
   a. Manufacturers' Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.

B. Product Schedule:
1. For exit signs.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing laboratory providing photometric data for luminaires.

B. Product Test Reports: For each luminaire for tests performed by manufacturer and witnessed by a qualified testing agency.

C. Sample Warranty: For manufacturer's special warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For luminaires and lighting systems to include in emergency, operation, and maintenance manuals.
   1. Provide a list of all lamp types used on Project; use ANSI and manufacturers' codes.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering before shipping.

1.8 WARRANTY

A. Warranty Period: Two year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 EXIT SIGNS

A. General Requirements for Exit Signs: Comply with UL 924; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction. Exit signs that can be read “TIXE” shall not be permitted.

B. Internally Lighted Signs:
   1. Operating at nominal voltage of 120 V ac.
   2. Lamps for AC Operation: LEDs; 50,000 hours minimum rated lamp life.

2.2 METAL FINISHES

A. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

2.3 LUMINAIRE SUPPORT COMPONENTS

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

B. Support Wires: ASTM A 641/A 641M, Class 3, soft temper, zinc-coated steel, 12 gage (2.68 mm).

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for conditions affecting performance of luminaires.

B. Examine roughing-in for luminaire to verify actual locations of luminaire and electrical connections before luminaire installation.

C. Examine walls, floors, roofs, and ceilings for suitable conditions where exit lighting will be installed.

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

3.2 INSTALLATION

A. Comply with NECA 1, “Standard Practice for Good Workmanship in Electrical Construction.”

B. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.

3.3 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

END OF SECTION

SECTION 28 46 21.11 - ADDRESSABLE FIRE-ALARM SYSTEM

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.

~~A.~~B. Refer to Section 087100 “Door Hardware” for components to be supplied and installed under Division 28.

1.2 SUMMARY

A. Section Includes:
1. Manual fire-alarm boxes.
2. System smoke detectors.
3. Notification appliances.

1.3 DEFINITIONS

A. EMT: Electrical Metallic Tubing.

B. FACP: Fire Alarm Control Panel.

C. HLI: High Level Interface.

D. NICET: National Institute for Certification in Engineering Technologies.

E. PC: Personal computer.

F. VESDA: Very Early Smoke-Detection Apparatus.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product, including furnished options and accessories.

1. Include construction details, material descriptions, dimensions, profiles, and finishes.
2. Include rated capacities, operating characteristics, and electrical characteristics.

B. General Submittal Requirements:

1. Submittals shall be approved by authorities having jurisdiction prior to submitting them to Architect.
2. Shop Drawings shall be prepared by persons with the following qualifications:

a. Trained and certified by manufacturer in fire-alarm system design.
b. NICET-certified, fire-alarm technician; Level III minimum.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Field quality-control reports.

1.6 SAMPLE WARRANTY: For special warranty.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: Personnel shall be trained and certified by manufacturer for installation of units required for this Project.

B. Installer Qualifications: Installation shall be by personnel certified by NICET as fire-alarm Level III technician.

C. NFPA Certification: Obtain certification according to NFPA 72 by a UL-listed alarm company.

1.8 PROJECT CONDITIONS

A. Perform a full test of the existing system prior to starting work. Document any equipment or components not functioning as designed.

B. Use of Devices during Construction: Protect devices during construction unless devices are placed in service to protect the facility during construction.

1.9 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace fire-alarm system equipment and components that fail in materials or workmanship within specified warranty period.

1. Warranty Extent: No extended warranty or service contract.
2. Warranty Period: Manufacturer’s Standard Warranty, but not less than one year.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Noncoded, UL-certified addressable system, with multiplexed signal transmission and voice/strobe evacuation.

B. Automatic sensitivity control of certain smoke detectors.

C. All components provided shall be listed for use with the selected system.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 MANUAL FIRE-ALARM BOXES

A. Manufacturers: Shall be compatible and match existing devices.

B. General Requirements for Manual Fire-Alarm Boxes: Comply with UL 38. Boxes shall be finished in red with molded, raised-letter operating instructions in contrasting color; shall show visible indication of operation; and shall be mounted on recessed outlet box. If indicated as surface mounted, provide manufacturer's surface back box.
   1. Double-action mechanism requiring two actions to initiate an alarm pull-lever type; with integral addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to fire-alarm control unit.
   2. Station Reset: Key- or wrench-operated switch.
   3. Indoor Protective Shield: Factory-fabricated, clear plastic enclosure hinged at the top to permit lifting for access to initiate an alarm. Lifting the cover actuates an integral battery-powered audible horn intended to discourage false-alarm operation.

2.3 NOTIFICATION APPLIANCES

A. Manufacturers: Shall be compatible and match existing devices.

B. General Requirements for Notification Appliances: Individually addressed, connected to a signaling-line circuit, equipped for mounting as indicated, and with screw terminals for system connections.

   1. Combination Devices: Factory-integrated audible and visible devices in a single-mounting assembly, equipped for mounting as indicated, and with screw terminals for system connections.

C. Visible Notification Appliances: Xenon strobe lights complying with UL 1971, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate. The word "FIRE" is engraved in minimum 1-inch- (25-mm-) high letters on the lens.

   1. Rated Light Output:

      a. 15/30/75/110 cd, selectable in the field.

   2. Mounting: Wall mounted unless otherwise indicated.
   3. For units with guards to prevent physical damage, light output ratings shall be determined with guards in place.
   4. Flashing shall be in a temporal pattern, synchronized with other units.
   5. Strobe Leads: Factory connected to screw terminals.
   6. Mounting Faceplate: Factory finished, red.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for ventilation, temperature, humidity, and other conditions affecting performance of the Work.

1. Verify that manufacturer's written instructions for environmental conditions have been permanently established in spaces where equipment and wiring are installed, before installation begins.

B. Examine roughing-in for electrical connections to verify actual locations of connections before installation.

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

3.2 EQUIPMENT INSTALLATION

A. Comply with NFPA 72, NFPA 101, and requirements of authorities having jurisdiction for installation and testing of fire-alarm equipment. Install all electrical wiring to comply with requirements in NFPA 70 including, but not limited to, Article 760, "Fire Alarm Systems."

1. Devices placed in service before all other trades have completed cleanup shall be replaced.
2. Devices installed but not yet placed in service shall be protected from construction dust, debris, dirt, moisture, and damage according to manufacturer's written storage instructions.

B. Manual Fire-Alarm Boxes:

1. Install manual fire-alarm box in the normal path of egress within 60 inches (1520 mm) of the exit doorway.
2. Mount manual fire-alarm box on a background of a contrasting color.
3. The operable part of manual fire-alarm box shall be between 42 inches (1060 mm) and 48 inches (1220 mm) above floor level. All devices shall be mounted at the same height unless otherwise indicated.

C. Install a cover on each smoke detector that is not placed in service during construction. Cover shall remain in place except during system testing. Remove cover prior to system turnover.

D. Audible Alarm-Indicating Devices: Install not less than 6 inches (150 mm) below the ceiling. Install bells and horns on flush-mounted back boxes with the device-operating mechanism concealed behind a grille. Install all devices at the same height unless otherwise indicated.

E. Visible Alarm-Indicating Devices: Install adjacent to each alarm bell or alarm horn and at least 6 inches (150 mm) below the ceiling. Install all devices at the same height unless otherwise indicated.

F. Device Location-Indicating Lights: Locate in public space near the device they monitor.

3.3 PATHWAYS

A. Pathways shall be installed in EMT.

3.4 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Install framed instructions in a location visible from fire-alarm control unit.

3.5 GROUNDING

A. Ground fire-alarm control unit and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to fire-alarm control unit.

B. Ground shielded cables at the control panel location only. Insulate shield at device location.

3.6 FIELD QUALITY CONTROL

A. Field tests shall be witnessed by authorities having jurisdiction.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections.

D. Reacceptance Testing: Perform reacceptance testing for altered fire alarm system in accordance with 2013 NFPA 72 14.4.2.

E. Fire-alarm system will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

END OF SECTION