PROJECT MANUAL
Vol. 3 of 5
Divisions 21 - 23
10.21.16

NORM ASBJORNSON HALL

PPA #  13-0200
A/E #  2014-02-07
A&E #  14080

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### Architects: A&E / ZGF

### M-E-P Engineers: ACE / AEI

### Lab Consultant: RFD

### Civil, Geotech, Transportation, and Survey Engineers: DOWL HKM

### Structural Engineer: Morrison-Maierle

### Landscape Architect: Land Design

### Acoustic Consultant: Big Sky Acoustics

### Technology Consultant: Access Consulting

### Audio Visual Design: Onpoint Designs
PART 1 - GENERAL

1.1 SCOPE

A. Furnish and install an automatic sprinkler system and manual wet standpipe system to protect all areas of the new MSU Norm Asbjornson Hall building as indicated herein and as shown on the drawings. Connect system to a water supply of sufficient pressure to ensure full and sustained water discharge immediately from sprinkler heads when opened by fire at rated heat temperatures. Water supply shall conform to NFPA water supply requirements with considerations given to the reliability of the public water supply, taking into account probable minimum pressure conditions. The water supply characteristics at the point of the new water service connection to the existing water main are anticipated to be approximately: 78 PSI static, 66 PSI residual with 1,400 GPM flowing. Contractor shall obtain flow test that was performed within the past twelve months prior to submitting shop drawings for approval.

B. All portions of the systems shall be installed in accordance with the drawings, details, and specifications and as required by jurisdictional authorities and codes. The position is taken that the Owner is entitled to a project which meets or exceeds the minimum requirements of nationally recognized fire protection standards. All efforts and installations shall be directed toward this end. Where there is conflict between the contract drawings and/or specifications, and the requirements of the jurisdictional authorities or codes, the conflict shall be brought to the attention of the Engineer at least ten (10) days prior to bidding or be resolved at no cost to the Owner. If the contractor has not identified conflicts to the Engineer, he shall be responsible for complying with the most restrictive (expensive) methods.

C. The intent of these specifications is to describe the complete systems to be installed, including minor details of work or materials not specifically mentioned or shown on the drawings, but necessary for the successful operation and completion of the installation. Contractor shall provide all minor details of work or materials necessary for a complete system even if not specifically mentioned or shown on the drawings. This includes any fittings, offsets, valves, hangers, bracing or piping that may be necessary due to field conditions or coordination with other trades.

D. Work to be performed under this section shall include, but not be limited to the following:

1. Automatic Wet Pipe Fire Sprinkler System.
   a. Pipe and fittings.
   b. Hangers and supports.
   c. Earthquake bracing.
   d. Valves.
   e. Alarms.
   f. Flow and Tamper Switches.
   g. Specialties.

   a. Pipe and fittings.
   b. Hangers and supports.
   c. Earthquake bracing.
   d. Valves.
   e. Alarms.
   f. Flow and Tamper Switches.
   g. Specialties
E. Furnish and install an automatic fire protection system of type or types required in the following areas:

1. All areas of the building – Automatic Wet Pipe Fire Sprinkler system.
2. All required exit stairways– Manual Wet Class I Standpipe system.

1.2 RELATED WORK

A. All work performed under this section of the specifications shall be subject to the requirements of both the General and Special Conditions.

B. Related work specified elsewhere:

   Digital, Addressable Fire-Alarm System  Section 28 3 111

C. Examine the above referenced specification parts thoroughly before submitting a proposal for accomplishment of work in this section.

1.3 REGULATORY AGENCIES

A. The term jurisdictional authority used in this section of the specification shall include, as applicable, but not be limited to the following:

   1. City of Bozeman Building Department.
   3. Owner.

B. The design and installation of all systems of fire protection shall conform to all requirements of applicable codes and publications herein defined:

   5. All State and local ordinances
   6. Underwriters' Laboratories
   7. American Society of Testing Materials
   8. American National Standards Institute
   9. Occupational Safety and Health Administration

1.4 SUBMITTALS

A. General

   1. The successful Contractor shall provide submittal data as required under other portions of this specification.
   2. Work on the project shall not begin until submittals have been accepted by the Authority Having Jurisdiction and the Engineer.

B. Shop Drawings

   1. Submit shop drawings (floor plans - detailed working drawings), showing dimensions, ducts,
lights, or other items affecting the fire protection systems to jurisdictional agencies for review and approval. All items identified in NFPA #13 for proper working drawings shall be complied with. After approvals from jurisdictional agencies have been returned to the Contractor, they will be submitted to the Engineer for final review and approval.

2. Shop drawings shall be prepared in AutoCAD or compatible software.

C. Catalog/Product Information

1. Product data on all materials intended for use and as indicated on the drawings shall be submitted to the jurisdictional agencies and Engineer for approval. Product data submittals shall clearly indicate the proposed product to be used and include an index of all materials.

D. Hydraulic Calculations

1. Hydraulic calculations shall be submitted to the Authority Having Jurisdiction and Engineer for approval. Calculations shall be provided to substantiate all the pipe sizes shown on shop drawings.

E. Installer's Qualifications

1. All systems of fire protection shall be installed by a licensed (for the location of installation) Fire Protection Contractor, fully experienced in fire protection installation as required and specified herein.
2. All installers shall be competent and shall hold an endorsement by the State of Montana. Prior to beginning work, current Contractor's and Installer's license and endorsements shall be on file with the Department of Commerce Professional and Occupational Licensing Bureau (301 South Park, P.O. Box 200513, Helena, MT 59620-0513
3. Fire Protection Contractors may be required to provide in writing specific information as to successfully completed projects and references to show cause as to why they should be considered acceptable to the Engineer.

F. Close-Out

1. Record Drawings required per paragraph 1.6 and Operation and Maintenance Manuals required per paragraph 1.7, shall be submitted to the Engineer for approval.

1.5 JOB CONDITIONS

A. The Contractor shall investigate the structural, mechanical, electrical, and finished conditions affecting the piping, and shall arrange the equipment accordingly; furnishing required fittings, offsets and accessories. Route fire protection piping to avoid interference with duct work, piping and other building systems. In the event it becomes necessary to make field changes in pipe locations due to building construction, the Contractor shall consult with the system designer before making any changes. Any such changes required shall be made without additional costs.

B. The Contractor shall determine, and be responsible for, the proper locations and type of inserts for hangers, chases, sleeves, and other openings in the construction required for fire protection work, and shall obtain this information well in advance of the construction progress to avoid delay of the work.

C. The drawings indicate approximate locations of sprinkler heads and general concept routing of piping. Contractor is responsible for final locations and routing and shall be responsible for coordinating with other trades on site prior to system installation. Contractor shall review all contract documents including architectural, structural, mechanical, electrical, etc. for actual contract conditions.
D. All fees and permits specifically required for fire protection work, not obtained by others as specified elsewhere shall be applied for and paid for by this Contractor.

1.6 RECORD DRAWINGS

A. One approved set of drawings shall be maintained on the job at all times.

B. One set of “As-Built” drawings shall be kept on the job at all times. “As-Built” drawings shall be kept current daily. “As-Built” drawings shall be available at all times to Engineer for review and use.

C. One reproducible set of “As-Built” drawings shall be provided upon completion of the work.

1.7 OPERATION AND MAINTENANCE MANUALS

A. Three (3) final sets of operating and maintenance instructions shall be provided to the Owner upon completion. Manuals shall include, as a minimum, the following:

1. “As-Built” Drawings
2. Catalog cut sheets of all materials installed
3. Equipment maintenance manuals
4. Hydraulic Calculations
5. Acceptance Test Certificate
6. Certification of Owner Training
7. Contractor Guarantee and Warranty
8. “As-Built” AutoCAD drawing (.dwg) file or equal on CD

B. One (1) original copy of NFPA #25 (2011) shall be provided to the Owner.

C. Operation and Maintenance Manuals shall be submitted to the Engineer for approval within 14 days after final testing.

1.8 TRAINING

A. The Fire Protection Contractor shall instruct the Owner in the operation of the systems. Instruction shall continue until the Owner is fully satisfied that he understands the operation of his system.

B. Contractor shall obtain Owner’s dated signature that all training has been accomplished and is acceptable to the Owner.

1.9 GUARANTEES AND WARRANTIES

A. The Fire Protection Contractor shall guarantee to the Owner in writing, all equipment and workmanship for a period of one (1) year after the fire protection system has been placed in continuous service and has been accepted by all authorities having jurisdiction.

B. The Fire Protection Contractor shall not be held responsible for improper or negligent maintenance by the Owner after operating and maintenance indoctrination has been given to the Owner.

PART 2 - PRODUCTS
2.1 FIRE SPRINKLER SYSTEM EQUIPMENT

A. Where contract documents indicate specific model number or manufacturer; Contractor may substitute identical equipment approved for fire protection use.

2.2 AUTOMATIC SPRINKLERS

A. All sprinklers shall be of similar design and from a single manufacturer.

B. The operating temperature of sprinklers shall be as required by the specific location of installation in accordance with NFPA #13 requirements.

C. Sprinklers shall conform to the following schedule:
   1. Brass upright or pendent sprinklers may be used in all attic, mechanical, storage or other non-public spaces or areas where piping is exposed.
   2. White pendent sprinklers with white recessed escutcheons shall be used in all finished ceiling areas, corridors, bathrooms, offices, etc.
   3. White recessed sidewall sprinklers may be used in accordance with listing and jurisdictional requirements where approved by the Engineer.
   4. All sprinklers shall be quick-response type.
   5. White recessed dry pendent or dry sidewall sprinklers shall be used in vestibules and all areas subject to freezing when the sprinklers are supplied from a heated area wet system.

D. Manufacturers
   1. Tyco
   2. Victaulic
   3. Viking
   4. Reliable

2.3 PIPE AND FITTINGS

A. Interior piping for automatic sprinkler system shall conform to NFPA #13 and as follows.

B. Sprinkler piping above ground with threaded fittings shall be Schedule 40 black steel pipe.

C. Fittings for threaded and coupled pipe shall consist of cast iron or ductile threaded fittings joined with Teflon tape thread sealing compound or pipe joint compound. Pressure rating of fittings shall be as required for application.

D. Sprinkler piping above ground for sizes 2½” and larger may be Schedule 10 black steel pipe with grooved fittings.

E. Fittings for grooved end pipe shall consist of Tyco Grinnell Series or equal couplings and fittings in accordance with NFPA #13.

F. CPVC piping with solvent weld fittings may be used when installed in accordance with the U.L. listing requirements and manufacturer’s recommendations.

G. Fittings for plain end pipe shall not be used.
H. Flexible piping drops that are U.L. listed or FM approved shall be used where sprinkler heads are installed in suspended acoustical tile ceilings. Flexible pipe drops shall have stainless steel braided covers.

I. All drain and fire department connection piping and fittings down-stream of valves shall be galvanized. Malleable iron fittings are acceptable.

2.4 HANGERS AND SUPPORTS

A. Space pipe hangers in accord with the requirements of NFPA #13. Construct hangers, hanger rods, inserts and clamps as approved by the same.

B. Manufacturers:
   1. Tolco
   2. Afcon
   3. Erico
   4. Speedy Product (Super Screws)
   5. Elco (Hanger Mate)

C. Concrete hanger inserts shall be approved for use in Seismic Design category C or D.

2.5 EARTHQUAKE BRACING

A. Furnish and install all earthquake bracing and restraint as required by International Building Code, NFPA #13 and the authority having jurisdiction.

B. Bracing attachments shall be made to the top chord of open web steel bar joists, steel I-beams or concrete decking.

C. Concrete insert attachments used for seismic bracing shall be approved for use in Seismic Design category C or D.

D. Calculations shall be provided with the shop drawings to indicate the zone of influence for the seismic braces, bracing attachments to pipe and attachment to structure in accordance with NFPA #13.

2.6 VALVES

A. Gate valves shall be approved indicating type as required by NFPA #13 or NFPA #14. Check valves shall be as required by NFPA #13 or NFPA #14. Test and drain valves shall be approved brass globe, angle, or ball valves. Locate sprinkler system isolation control valves as shown on the drawings complete with a tamper alarm switch.

B. Interior
   1. Gate
      Make:    Nibco
      Sizes:    2½” through 4”
      Ends:    Flanged
      Model:    F-607-OTS
   2. Butterfly
C. All control valves, inspectors test valves and main drain valves shall be installed within six feet of the floor level for maintenance access.

D. Manufacturers:

1. Tyco
2. Nico
3. AGF
4. Victaulic
5. Reliable
6. Mueller
7. United Brass
8. Milwaukee

2.7 STANDPIPES

A. Provide manual wet Class I standpipes in each of the required exit stairways as indicated on the drawings.

B. Provide 2½" angle hose valves with 2½" NPT female inlet and 2½" male NSHT outlet complete with 2½"x 1½" hose thread reducer and 1½" cap and chain. Finish shall be polished brass.

C. Hose valves shall be installed 4'-0" above floor at stair landings and other locations as noted on plans.
D. Provide 4”x2½”x2½” roof manifold on the roof at each required stair. Each roof manifold to have two hose valves and accessories as indicated above. Install water pressure gauge at each roof manifold. Finish shall be polished brass.

E. Provide non-rising stem gate valve or butterfly valve below roof at top of stairway with post indicator on roof for control of each roof manifold. Install tamper switch on post indicator.

2.8 BACKFLOW PREVENTION DEVICES

A. Install new backflow prevention devices as required by the Water Authority having jurisdiction.

B. Devices shall be UL or FM approved.

C. All reduced pressure backflow prevention devices shall be provided with an air gap drain with splash guard and piped to the exterior or adequate floor drain with galvanized pipe and fittings.

D. The backflow prevention device shall be tested and certified by the installing contractor.

E. Manufacturers:
   1. Febco
   2. Ames
   3. Watts

2.9 FIRE DEPARTMENT CONNECTIONS

A. Furnish and install where shown on plans and approved by authority having jurisdiction fire department connections, complete with clapper snoots and Knox plugs.

B. Fire department connection shall be flush type and have four 2½” inlets to supply the standpipe demand. Finish shall be polished chrome.

C. Fire department connections shall be set 2'-6" above grade.

D. Fire department connections identification plate shall be indexed "AUTO. SPKR. / STANDPIPE". The indexing shall be "cast in" by the manufacturer. Required indexing shall be permanently installed at the connection. Finish shall be polished chrome.

E. Fire department connection shall be complete with interior independent self-closing clappers at each inlet, locking Knox plugs and shall have threads to meet the local fire department requirements.

F. Provide an automatic ball-drip drain at low point of piping between the fire department inlet connection and check valve.

G. Manufacturers:
   1. Potter Roemer
   2. Croker
   3. Powhatan
   4. Tyco
2.10 SPECIALTIES

A. Fire Seals
   1. Where piping passes through walls, floors or other building construction which by code requires a fire rating, approved fire rated assemblies shall be used. Proposed protection shall be submitted for approval. Review Architectural plans for locations of fire rated construction.

B. Escutcheon Plates
   1. Where approved exposed piping passes through finish work, chrome plated (or other finish acceptable to the Architect or Engineer) wall plates shall be installed. Split wall plates or escutcheons shall be installed to fit snugly around piping. All wall plates shall be metal.
   2. Solid galvanized wall plates shall be used at both sides of all exterior walls where piping passes through the exterior wall.

C. Valve Identification
   1. All valves within the building shall have permanently marked identification signs provided in accordance with NFPA #13 and NFPA #14 standards. Signs shall be manufactured and not hand written. Signs shall be hung with galvanized or chrome chain.

D. Spare Head Supply
   1. Furnish and install a supply of extra sprinklers (minimum of two) of each type and degree link installed in the project, complete with mountable box. Mount box on wall next to fire sprinkler system riser. Provide wrenches for each type of sprinkler installed in box.

2.11 ELECTRICAL DEVICES

A. All electrical devices shall be coordinated with Digital, Addressable Fire-Alarm System (Section 28 31 11) requirements for compatibility of voltages and manufacturer.

B. Flow Switch
   1. Potter VSR-F
   2. Potter VSR-SF

C. Tamper Switch
   1. Potter OSYSU-2
   2. Potter RBVS

D. Audio/Visual Alarm Indicating Appliances
   1. Audio/Visual units shall provide a common enclosure for the fire alarm audible and visual alarm devices. The housing shall be designed to accommodate either horns, bells, or chimes. The unit shall be complete with a tamper resistant, Pyramidal shaped lens with “Fire” lettering visible from a 180° field of view. Integral Xenon strobe shall provide a minimum light output of 4.5 candelas at 24VDC at a 45 flashes per minute rate. Xenon strobes shall provide a 4-wire connection to insure properly supervised in/out system connection. Unit shall be complete with all mounting hardware including backbox.
E. All flow switches and tamper switches shall be installed within six feet of the floor level for maintenance access.

F. Manufacturers:
   1. Potter Signal
   2. System Sensor

PART 3 - EXECUTION

3.1 DESIGN CRITERIA

A. Approximate sprinkler head arrangement and conceptual routing of piping is indicated on the drawings. The entire fire protection system including minor details of work and/or exact pipe routing may not be shown on the plans. The contractor is to provide a complete fire protection system per NFPA #13 and NFPA #14 as required and provide all necessary material and labor to provide the complete system.

B. The fire sprinkler contractor shall coordinate on site with other trades for routing of piping within the building.

C. All piping shall be run concealed wherever possible. Where piping is run exposed, special notation on drawings to that effect shall be evident and conspicuous on the drawings. Any piping determined to be a problem by the Architect or Engineer shall be relocated at no additional cost.

D. Pendent sprinklers installed in suspended acoustical tile ceilings shall be centered or quarter pointed within the ceiling tile. Pendent sprinklers shall be a minimum of 6" from the suspended ceiling grid.

E. System piping shall be hydraulically calculated in accordance with NFPA #13 and NFPA #14 to the point of connection verified for flow characteristics.

F. The fire protection systems design, including shop drawings and hydraulic calculations, shall be accomplished by a Professional Engineer competent in fire protection or by a NICET Level III fire sprinkler system design technician.

G. Contractor shall provide isolation control valves with tamper switches and auxiliary drains where indicated on the drawings.

3.2 INSTALLATION

A. Where details of installation are not given, the installation shall be made using manufacturer's recommended practices or at the direction of the Engineer.

B. All control valves, inspectors test valves, main drain valves, flow switches, tamper switches and any other equipment that requires regular maintenance, inspection or testing shall be installed within six feet of the floor level for maintenance access.

C. The contractor shall be responsible for providing all labor and material for a complete system in accordance with these specifications and applicable standards and Codes. Contractor shall provide all material and labor as necessary for any changes that may be necessary due to field conditions from the shop drawings submitted for approval. All necessary changes shall be made at no additional cost to the Owner.
D. Contractor shall complete the fire protection systems ready for operation, in all respects, as soon as possible. When system is complete and ready for continuous operation, activate the system for its intended use. After system has been activated for continuous use, water charges will be paid by the Owner.

E. This Contractor shall remove from the building, all rubbish and unused materials due to or connected with this installation.

F. The surface of all piping shall be cleaned and left ready for painting. This includes the removal of any stickers or tags on the piping.

3.3 TESTING

A. All testing shall be accomplished in accord with NFPA standards and requirements.

B. This Contractor shall call for inspection and complete Contractor’s Material and Test Certificates signed by the authority having jurisdiction.

C. The entire sprinkler and standpipe system shall be hydrostatically tested at not less than 200 psig pressure for a period of not less than two (2) hours or 50 psi above static pressure in excess of 150 psi for two (2) hours with no pressure drop in the system.

D. The standpipe system shall be flow tested in accordance with NFPA #14 requirements.

E. The backflow prevention device shall be tested and certified as required by the local water authority and applicable codes.

F. All testing shall be witnessed by a representative of the Engineer or Owner and the authority having jurisdiction.

G. Where jurisdictional authority’s standards are more stringent than the above test, they shall prevail.

H. Furnish copies of all test certificates with close-out documentation.

END OF SECTION 21 13 13
SECTION 22 00 00 - PLUMBING GENERAL REQUIREMENTS

PART 1 - GENERAL

1.1 MECHANICAL REQUIREMENTS

A. The mechanical requirements are supplemental to the General Requirements of these Specifications. The Mechanical Sections shall apply to phases of the work specified, shown on the Drawings, or required to provide for the complete installation of Mechanical Systems for this project.

B. The work shall include all items, articles, materials, operations and methods listed, mentioned, or scheduled in these specifications and the accompanying drawings. All material, equipment, and labor shall be furnished together with all incidental items required by good practice to provide the complete systems described.

C. Examine and refer to all Architectural, Civil, Structural, Electrical, Utility, Landscape and Mechanical drawings and specifications for construction conditions which may affect the mechanical work. Inspect the building site and existing facilities for verification of present conditions. Make proper provisions for these conditions in performance of the work and cost thereof.

D. See general requirements for listed Alternate Bids. Note alternates listed and include any changes in work and price required to meet the requirements of the respective alternate.

1.2 LEED REQUIREMENTS

A. LEED requirements for this project are as follows:

1. Meet LEED standards for all LEED prerequisites and the particular LEED Credits chosen as part of this project. The Following items are only a portion of the LEED points being pursued.

2. Meet ASHRAE 90.1-2007 in all respects for material and methods (this is a requirement of LEED Credit EA-1.0 Optimize Energy Efficiency). These requirements are included throughout the specification.

3. LEED Credit EQ4.1 requires that Adhesives and Sealants be low in VOC’s. See Piping Specifications for VOC content limitations. Submit this information as part of the Shop Drawings.

4. LEED EA Prerequisite 1 and Credits 3 are included and consist of Commissioning of Building Energy Systems. The mechanical contractor shall be responsible for accommodating the commissioning agent in his work. See the Commissioning Specifications.

5. LEED EA Prerequisite 3 and Credit 4 are being pursued. This includes Refrigeration Management directed at reducing impact of refrigerant on the atmosphere. Specific refrigerants are specified to reduce this. Refrigerant substitutions will be disallowed or carefully scrutinized for this reason.

6. Note the specific requirements of EQ Credit 3.1: Construction IAQ during construction. Work shall be done in accordance with SMACNA’s IAQ Guidelines for Occupied Buildings Under Construction, 1995, Chapter 3. Reference this manual for measures to protect the building workers and the building HVAC system during construction and demolition activities. Keep a copy of this standard on site for reference throughout the project.

7. Please refer to Section 01 81 13.13 for Sustainable Design Requirements.

1.3 CODES AND STANDARDS
A. Work shall meet the requirements of the plans and specifications and shall not be less than the minimum requirements of applicable sections of the latest Codes and Standards of the following Organizations:

1. American Society of Mechanical Engineers (ASME)
2. American Water Works Association (AWWA)
3. National Electrical Code (NEC)
4. National Electrical Manufacturers Association (NEMA)
5. National Fire Protection Association (NFPA)
6. Uniform Plumbing Code
7. Occupational Safety & Health Act (OSHA)
8. Plastic Pipe Institute (PPI)
9. Sheet Metal and Air Conditioning Contractors National Association (SMACNA)
10. International Mechanical Code (IMC)
12. Requirements of the Serving Utility Company
13. Local and State Codes and Ordinances
14. SMACNA Seismic Manual

1.4 FEES AND PERMITS

A. The Mechanical Contractor shall pay all fees and arrange for all permits required for work done under his contract and under his supervision by subcontract.

B. All usage contracts between the Owner and the serving utilities company, such as membership and usage charges or fees, etc., for the purpose of obtaining the services for the utility company shall be applied for and paid for by the Owner.

C. All permits and fees for connection to the utility, including inspection and staking costs imposed by the utility company or required for proper installation, and all necessary manholes, encasements, valves, service boxes, meters, meter housings or vaults complete as required by the utility company of jurisdictional agency, shall be applied for and paid by the Mechanical Contractor.

D. Exception: The gas service from the main to and including the gas meter will be furnished and installed by the gas company and paid for by the Owner.

1.5 MATERIALS AND EQUIPMENT

A. Manufacturers trade names and catalog numbers listed are intended to indicate the quality of equipment or materials desired. Manufacturers not listed must have prior approval. Written prior approval must be obtained from the Architect/Engineer ten (10) days prior to bid opening. Requests are to be submitted sufficiently ahead of the deadline to give ample time for examination. The items approved will be listed in an addendum and only this list of equipment will be accepted in lieu of specified products. Submittals must indicate the specific item or items to be furnished in lieu of those specified, together with complete technical and comparative data on specified items and proposed items. See list of prior approved manufacturers at end of this section.

B. Mechanical equipment may be installed with manufacturer’s standard finish and color except where specific color, finish or choice is indicated. If the manufacturer has no standard finish, equipment shall have a prime coat and two finish coats of gray enamel.
C. This Contractor shall be responsible for materials and equipment installed under this contract. Contractor shall also be responsible for the protection of materials and equipment of others from damage as a result of his work.

D. Manufactured material and equipment shall be applied, installed, connected, erected, used, cleaned and conditioned as directed by manufacturer unless herein specified to the contrary.

E. This Contractor shall make the required arrangement with General Contractor for the introduction into the building of equipment too large to pass through finished openings.

F. Store materials and equipment indoors at the job site or, if this is not possible, store on raised platforms and protect from the weather by means of waterproof covers. Coverings shall permit circulation of air around the materials to prevent condensation of moisture. Screen or cap openings in equipment to prevent the entry of vermin.

1.6 INTENT OF DRAWINGS

A. The drawings are partly diagrammatic and do not necessarily show exact location of piping and ductwork unless specifically dimensioned. Riser and other diagrams are schematic and do not necessarily show the physical arrangement of the equipment. They shall not be used for obtaining lineal runs of piping or ductwork, nor shall they be used for shop drawings for piping and ductwork fabrication or ordering. Discrepancies shown on different plans, or between plans and actual field conditions shall be brought to the attention of the Architect/Engineer for resolution.

1.7 RESPONSIBILITY

A. The Mechanical Contractor shall be responsible for the installation of a satisfactory and complete system in accordance with the intent of the drawing and specifications. Provide, at no extra cost, all incidental items required for completion of the work even though they are not specifically mentioned or indicated on the drawings or in the specifications.

B. The drawings do not attempt to show complete details of the building construction which affect the mechanical installation; and reference is therefore required to the Architectural, Civil, Structural, Landscape and Electrical drawings and specifications and to shop drawings of all trades for additional details which affect the installation of the work covered under this Division of the Contract.

C. Location of mechanical system components shall be checked for conflicts with openings, structural members and components of other systems having fixed locations. In the event of any conflicts, the Architect/Engineer shall be consulted and his decision shall govern. Necessary changes shall be made at the Contractor’s expense.

D. Determine, and be responsible for, the proper location and character of inserts for hangers, chases, sleeves, and other openings in the construction required for the work, and obtain this information well in advance of the construction progress so work will not be delayed.

E. Final location of inserts, hangers, etc., required for each installation, must be coordinated with facilities required for other installations to prevent interference.

F. Take extreme caution not to install work that connects to equipment until such time as complete Shop Drawings of such equipment have been approved by the Architect/Engineer. Any work installed by the Contractor, prior to approval of Shop Drawings, will be at the Contractor’s risk.
G. At all times during the performance of this Contract, properly protect work from damage and protect the Owner's property from injury of loss. Make good any damage, injury or loss, except such as may be directly due to errors in the Bidding Documents or caused by Agents or Employees of the Owner. Adequately protect adjacent property as provided by law and the Bidding Documents. Provide and maintain passageways, guard fences, lights and other facilities for protection required by Public Authority or Local conditions.

H. The Contractor shall be responsible for damages due to the work of their Contractors, to the building or its contents, people, etc.

1.8 REVIEW

A. All work and material is subject to review at any time by the Architect/Engineer or his representative. If the Architect/Engineer or his representative finds material that does not conform with these specifications or that is not properly installed or finished, correct the deficiencies in a manner satisfactory to the Architect/Engineer at the Contractor’s expense.

1.9 WORKMANSHIP

A. GENERAL

1. Work under this contract shall be performed by workmen skilled in the particular trade, including work necessary to properly complete the installation in a workmanlike manner to present a neat and finished appearance.

B. EXCAVATION AND BACKFILL

1. Provide all excavating and backfilling as required, with backfilling only after approval of the Architect. Backfill to be free of all debris and decayable matter. See Excavation and Backfill requirements in SECTION 31 20 00 – EARTH MOVING.

C. CUTTING, PATCHING, AND FRAMING

1. Obtain Architect’s/Engineer’s approval before performing any cutting on structural members or patching of building surfaces. Any damage to the building or equipment by this Contractor shall be the responsibility of this Contractor and shall be repaired by skilled craftsmen of the trades involved at the Contractor’s expense.

2. Chases, openings, sleeves, hangers, anchors, recesses, equipment pads, framing for equipment, provided by others only if so noted on the drawings. Otherwise, they will be provided by this Contractor for his work. Whether chases, etc., are provided by this Contractor or others, this Contractor is responsible for correct size and locations.

1.10 COORDINATION

A. This Contractor shall plan his work to proceed with a minimum interference with other trades and it shall be his responsibility to inform the General Contractor of all openings required in the building structure for installation of work, and to provide sleeves as required. Dimensions of equipment installed and/or provided by others shall be checked in order that correct clearances and connections may be made.

1.11 CLEAN UP
A. Keep the premises free from accumulation of waste material or rubbish caused by his work or employees.

B. Upon completion of work, remove materials, scraps and debris relative to his work and leave the premises, including tunnels, crawl spaces, and pipe chases in clean and orderly condition. Remove all dirt and debris from the interior and exterior of all devices and equipment. After construction is completed, wash all mechanical equipment.

1.12 DUST PROTECTION

A. Contractor will provide suitable dust protection for all existing areas prior to beginning of cutting or demolition. Contractor will obtain approval of partition from Owner before proceeding with work involved in these rooms.

1.13 TEMPORARY FACILITIES

A. OFFICES

1. Contractor may provide a temporary office for himself and for the periodic use by the Architect\Engineer.

B. REMOVAL

1. Contractor shall completely remove his temporary installations when no longer needed and the premises shall be completely clean, disinfected, patched, and refinished to match adjacent areas.

C. LADDERS AND SCAFFOLDS

1. The Contractor shall provide their own ladders, scaffolds, etc. of substantial construction for access to their work in various portions of the building as may be required. When no longer needed, they shall be removed by the Contractor.

D. PROTECTION DEVICES

1. The Contractor shall provide and maintain his own necessary barricades, fences, signal lights, etc., required by all governing authorities or shown on the drawings. When no longer needed, they shall be removed by the Contractor. The Contractor shall assume all responsibility for which the Owner may be held responsible because of lack of above items.

E. TEMPORARY WATER

1. The Contractor shall provide all water required by his trade for construction. Temporary drinking water shall be provided by Contractor from a proven safe source dispensed by single service containers, until such time as the construction water outlet has been installed, disinfected, and approved for drinking purposes.

F. TEMPORARY FIRE PROTECTION

1. The Contractor shall provide all necessary first-aid hand fire extinguishers for Class A, B, C and special hazards as may exist in his own work area only in accordance with good and safe practice and as required by jurisdictional safety authority. The Contractor shall provide general area fire extinguishers only.
1.14 SHOP DRAWINGS

A. Provide eight PDF Electronic Submittals of manufacturer’s literature and/or certified prints as soon as possible but within thirty (30) days after awarding of Contract, for items of materials, equipment, or systems where called for in specifications. Shop drawings and literature complete showing item used, size, dimensions, capacity, rough-in, etc., as required for complete check and installation. Manufacturers literature showing more than one item shall be clearly marked as to which item is being furnished or it will be rejected and returned without review.

B. Each copy of each item submitted must be clearly marked as follows for purposes of identification and record. Submittals not marked (typewritten only) as described below will be rejected and returned without review.

   Date:
   Name of Project:
   Branch of Work:
   Submitted by:
   Specification or Plan Reference:

C. Prior to their submission, each submittal shall be thoroughly checked by the Contractor for compliance with the Contract Document requirements, accuracy of dimensions, relationship to the work of other trades, and conformance with sound, safe practices as to erection and installation. Each submittal shall then bear a stamp evidencing such checking and shall show corrections made, if any. Submittals requiring extensive corrections shall be revised before submission. Each submittal not stamped and signed by the Contractor evidencing such checking will be rejected and returned without review.

D. All submittals will be examined when submitted in proper form for compliance. Such review shall not relieve the Contractor of responsibility for errors, for deviation from the contract Documents, nor for violation of sound safety practices.

E. The Contractor shall keep in the field office one print of each submittal which has been reviewed and stamped by the Architect or Engineer.

F. Submittals will be required for each item of material and equipment furnished as noted in specifications.

G. Submittals which are incomplete relative to quality requirements, capacity, engineering data, dimensional data or detailed list of specialty or control equipment will be rejected. Lists shall include descriptive coding as specified or shown on drawings.

   THE ENGINEER WILL PERFORM SHOP DRAWING REVIEW OF EACH ITEM; HOWEVER, SUBSEQUENT REVIEW OF ITEMS PREVIOUSLY REJECTED WILL BE BILLED TO THE CONTRACTOR AT A RATE OF $100 PER HOUR.

H. Schedule of Shop Drawings.

   1. 22 05 13  COMMON MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT
   2. 22 05 17  SLEEVES AND SLEEVE SEALS FOR PLUMBING PIPING
   3. 22 05 18  ESCUTCHEONS FOR PLUMBING PIPING
   4. 22 05 19  METERS AND GAGES FOR PLUMBING PIPING
   5. 22 05 23.12 BALL VALVES FOR PLUMBING PIPING
   6. 22 05 23.14 CHECK VALVES FOR PLUMBING PIPING
   7. 22 05 23.15 GATE VALVES FOR PLUMBING PIPING
   8. 22 05 29  HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT
   9. 22 05 48  VIBRATION AND SEISMIC CONTROLS FOR PLUMBING PIPING AND EQUIPMENT
  10. 22 05 53  IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT
  11. 22 07 19  PLUMBING PIPING INSULATION
12. 22 11 13 FACILITY WATER DISTRIBUTION PIPING
13. 22 11 16 DOMESTIC WATER PIPING
14. 22 11 19 DOMESTIC WATER PIPING SPECIALTIES
15. 22 13 13 FACILITY SANITARY SEWERS
16. 22 13 16 SANITARY WASTE AND VENT PIPING
17. 22 13 19 SANITARY WASTE PIPING SPECIALTIES
18. 22 13 29 SANITARY SEWERAGE PUMPS
19. 22 14 13 FACILITY STORM DRAINAGE PIPING
20. 22 14 23 STORM DRAINAGE PIPING SPECIALTIES
21. 22 15 13 GENERAL-SERVICE COMPRESSED-AIR PIPING
22. 22 15 19 GENERAL-SERVICE PACKAGED AIR COMPRESSORS AND RECEIVERS
23. 22 35 00 DOMESTIC WATER HEAT EXCHANGERS
24. 22 35 13 MODULAR SCROLL CHILLER/HEAT PUMP FOR DOMESTIC WATER HEATING
25. 22 42 13.13 COMMERCIAL WATER CLOSETS
26. 22 42 13.16 COMMERCIAL URINALS
27. 22 42 16.13 COMMERCIAL LAVATORIES
28. 22 42 16.16 COMMERCIAL SINKS
29. 22 45 00 EMERGENCY PLUMBING FIXTURES
30. 22 47 16 PRESSURE WATER COOLERS
31. 22 66 00 CHEMICAL-WASTE SYSTEMS FOR LABORATORY AND HEALTHCARE FACILITIES

I. Submittals shall be properly bound in a PDF or equivalent method. Incomplete submittals shall be returned without review.

1.15 OPERATION AND MAINTENANCE MANUALS

A. At the time orders are placed for any item of equipment requiring service or operating maintenance, the Contractor shall request the manufacturer furnish three (3) copies of OPERATION AND MAINTENANCE INSTRUCTIONS for each piece of equipment. These shall be included in the brochure of equipment.

1.16 BROCHURE OF EQUIPMENT

A. Upon completion of work, prepare three copies of "Brochure of Equipment" containing data pertinent to equipment and systems on job. Binders containing materials shall be one or more three ring binders of sufficient number to hold all literature. Contained in binders shall be: Installation, maintenance, and operating instructions for each piece of equipment; parts lists; wiring diagrams; one copy of each shop drawing and literature submittal; record drawings, etc.

B. All literature shall be clean, unused and filed under divider headings corresponding to the specifications.

C. These brochures shall be submitted to the Architect/Engineer and approved by him before authorization of final payment.

1.17 AS-BUILT DRAWINGS

A. The Contractor shall furnish to the Owner and Architect/Engineer a marked print showing the location of all concealed or underground pipe or conduit runs and other equipment installed other than as shown on the drawings. Dimension underground lines from established building lines. Indicate all installed pull boxes in conduit runs.
B. The Contractor shall furnish to the Architect/Engineer a marked print showing the location of all mechanical equipment, plumbing fixtures, piping, etc. The location of any item which deviates from the bid documents shall be accurately drawn and dimensioned.

C. All underground piping shall be dimensioned from nearest column and/or exterior walls. The location of all maintenance related items such as duct access doors, fire dampers, isolation valves, filters, etc., shall be highlighted on as built drawing.

1.18 PLACING SYSTEMS IN OPERATION

A. At the completion of the work and at such time as the Owner shall direct, prior to final acceptance, the Contractor performing this work shall put into satisfactory operation the various systems installed under the specifications. At no additional cost to the Owner, furnish the services of a person completely familiar with the installations performed under this specification, to instruct the Owner’s operating personnel in the proper operation and servicing of the equipment and systems. These services shall be available for a period of no less than one (1) day.

1.19 WARRANTY

A. The Contractor shall guarantee that all materials and labor installed are new and of first quality and that any material or labor found defective shall be replaced without cost to the Owner within one (1) year after substantial completion of the Contract or one (1) full season of heating and cooling operation, whichever is the greater. The guarantee shall list the date of the beginning of the one (1) year period, which shall be the date that the Substantial Completion Certificate is issued.

B. Any damage to the building, caused by defective work or material of the Contractor within the above-mentioned period, shall be satisfactorily repaired without cost to the Owner.

C. The guarantee does not include maintenance of equipment. The Owner shall accept full responsibility for proper operation and maintenance of equipment immediately upon substantial completion and occupancy of the building.

D. Final acceptance by the Owner will not occur until all operating instructions are mounted in Equipment Rooms and Operating Personnel thoroughly indoctrinated in the operation of all mechanical equipment by the Contractor.

1.20 TRAINING

A. Training will be performed for each system installed. Training is to be two separate identical sessions, held on separate weeks. A training Agenda will be developed by the Commissioning Authority. Contractor is responsible to have a competent party perform training, preferably the site foreman in conjunction with manufacturer’s representatives.

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

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:
   1. Piping materials and installation instructions common to most piping systems.
   2. Dielectric fittings.
   3. Mechanical sleeve seals.
   4. Sleeves.
   5. Escutcheons.
   7. Plumbing demolition.
   8. Equipment installation requirements common to equipment sections.
   9. Concrete bases.
  10. Supports and anchorages.

1.2 DEFINITIONS

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

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

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

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

E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

1.3 SUBMITTALS

A. Welding certificates.

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

PART 2 - PRODUCTS

2.1 PIPE, TUBE, AND FITTINGS

A. Refer to individual Division 22 piping Sections for pipe, tube, and fitting materials and joining methods.

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

2.2 JOINING MATERIALS

A. Refer to individual Division 22 piping Sections for special joining materials not listed below.

B. Pipe-Flange Gasket Materials: ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.

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

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

E. Brazing Filler Metals: AWS A5.8, BCuP Series or BAg1, unless otherwise indicated.


G. Solvent Cements for Joining Plastic Piping:

1. ABS Piping: ASTM D 2235.
2. CPVC Piping: ASTM F 493.
3. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.
4. PVC to ABS Piping Transition: ASTM D 3138.

2.3 DIELECTRIC FITTINGS

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

B. Insulating Material: Suitable for system fluid, pressure, and temperature.
C. Dielectric Unions: Factory-fabricated, union assembly, for 250-psig minimum working pressure at 180 deg F.

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

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

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

2.4 MECHANICAL SLEEVE SEALS

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

B. Sealing Elements: EPDM interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.

C. Pressure Plates: Stainless steel. Include two for each sealing element.

D. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.5 SLEEVES

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

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

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

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

1. Underdeck Clamp: Clamping ring with set screws.

E. Molded PVC: Permanent, with nailing flange for attaching to wooden forms.


G. Molded PE: Reusable, PE, tapered-cup shaped, and smooth-outer surface with nailing flange for attaching to wooden forms.

2.6 ESCUTCHEONS

A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.
B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished chrome-plated finish.

C. One-Piece, Cast-Brass Type: With set screw.
   1. Finish: Polished chrome-plated.

D. Split-Casting, Cast-Brass Type: With concealed hinge and set screw.
   1. Finish: Polished chrome-plated.

2.7 GROUT

A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.
   2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 PIPING SYSTEMS - COMMON REQUIREMENTS

A. Install piping according to the following requirements and Division 22 Sections specifying piping systems.

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

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

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

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

F. Install piping to permit valve servicing.

G. Install piping at indicated slopes.

H. Install piping free of sags and bends.

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

J. Install piping to allow application of insulation.

K. Select system components with pressure rating equal to or greater than system operating pressure.
L. Install escutcheons for penetrations of walls, ceilings, and floors.

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

N. 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.

O. 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.

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

Q. Verify final equipment locations for roughing-in.

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

3.2 PIPING JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 22 Sections specifying piping systems.

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

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

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


F. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

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

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

I. Plastic Piping Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
   1. Comply with ASTM F 402, for safe-handling practice of cleaners, primers, and solvent cements.
   2. 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 Nonpressure Piping: Join according to ASTM D 2855.
   6. PVC to ABS Nonpressure Transition Fittings: Join according to ASTM D 3138 Appendix.

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

K. Plastic Nonpressure Piping Gasketed Joints: Join according to ASTM D 3212.

L. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D 2657.
   1. Plain-End Pipe and Fittings: Use butt fusion.
   2. Plain-End Pipe and Socket Fittings: Use socket fusion.

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

3.3 PIPING CONNECTIONS

A. Make connections according to the following, unless otherwise indicated:
   1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.
   2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.
   3. Dry Piping Systems: Install dielectric unions and flanges to connect piping materials of dissimilar metals.
3.4 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 plumbing equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.

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

3.5 CONCRETE BASES

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

1. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit.
2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of the base.
3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to supported equipment.
6. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
7. Use 3000-psi, 28-day compressive-strength concrete and reinforcement as specified in Division 03 Section "Cast-in-Place Concrete or Miscellaneous Cast-in-Place Concrete."

3.6 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Refer to Division 05 Section "Metal Fabrications" for structural steel.

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

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

3.7 ERECTION OF WOOD SUPPORTS AND ANCHORAGES

A. Cut, fit, and place wood grounds, nailers, blocking, and anchorages to support, and anchor plumbing 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 plumbing equipment base bearing surfaces, pump and other equipment base plates, and anchors.

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

C. Provide forms as required for placement of grout.

D. Avoid air entrapment during placement of grout.

E. Place grout, completely filling equipment bases.

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

G. Place grout around anchors.

H. Cure placed grout.

END OF SECTION 22 05 00
SECTION 22 05 13 - COMMON MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT

PART 1 - GENERAL

1.1 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.

1.2 COORDINATION
A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:
   1. Motor controllers.
   2. Torque, speed, and horsepower requirements of the load.
   3. Ratings and characteristics of supply circuit and required control sequence.
   4. Ambient and environmental conditions of installation location.

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS
A. Comply with NEMA MG 1 unless otherwise indicated.

2.2 MOTOR CHARACTERISTICS
A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet above sea level.
B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.3 POLYPHASE MOTORS
A. Description: NEMA MG 1, Design B, medium induction motor.
B. Efficiency: Energy efficient, as defined in NEMA MG 1.
C. Service Factor: 1.15.
D. Multispeed Motors: Variable torque.
   1. For motors with 2:1 speed ratio, consequent pole, single winding.
2. For motors with other than 2:1 speed ratio, separate winding for each speed.


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

G. Temperature Rise: Match insulation rating.

H. Insulation: Class F.

I. Code Letter Designation:

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

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

2.4 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

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

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

1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
2. Energy- and Premium-Efficient Motors: Class B temperature rise; Class F insulation.
3. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

2.5 SINGLE-PHASE MOTORS

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

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

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

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

D. Motors 1/20 HP and Smaller: Shaded-pole type.
E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

PART 3 - EXECUTION

3.1 TRAINING

A. Training will be performed for each system installed. Training is to be two separate identical sessions, held on separate weeks. A training Agenda will be developed by the Commissioning Authority. Contractor is responsible to have a competent party perform training, preferably the site foreman in conjunction with manufacturer’s representatives.

END OF SECTION 22 05 13
PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Sleeves.
   2. Sleeve-seal systems.

1.2 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.1 SLEEVES

A. Cast-Iron Wall Pipes: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.

B. Galvanized-Steel Wall Pipes: ASTM A 53/A 53M, Schedule 40, with plain ends and welded steel collar; zinc coated.

C. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, with plain ends.


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

2.2 SLEEVE-SEAL SYSTEMS

A. Sleeve-seal systems in this article are used for piping penetrations in slabs-on-grade and below grade in exterior walls. These systems are available for NPS 1/2 to NPS 48 (DN 15 to DN 1200) piping.

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

   1. Advance Products & Systems, Inc.
   2. CALPICO, Inc.
   3. Metraflex Company (The).
   4. Pipeline Seal and Insulator, Inc.
   5. Proco Products, Inc.
C. Description: Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.

1. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
2. Pressure Plates: Stainless steel.
3. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements.

2.3 GROUT


B. Characteristics: Nonshrink; recommended for interior and exterior applications.

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

D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

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

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

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

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

1. Cut sleeves to length for mounting flush with both surfaces.
   a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level.

2. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.

D. Install sleeves for pipes passing through interior partitions.

1. Cut sleeves to length for mounting flush with both surfaces.
2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Comply with requirements for sealants specified in Section 07 92 00 "Joint Sealants."
E. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Section 07 84 13 "Penetration Firestopping."

3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

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

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

3.3 SLEEVE AND SLEEVE-SEAL SCHEDULE

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

1. Exterior Concrete Walls above Grade:
   a. Piping Smaller Than NPS 6: Cast-iron wall sleeves.
   b. Piping NPS 6 and Larger: Cast-iron wall sleeves.

2. Exterior Concrete Walls below Grade:
   a. Piping Smaller Than NPS 6: Cast-iron wall sleeves with sleeve-seal system.
      1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
   b. Piping NPS 6 and Larger: Galvanized-steel wall sleeves with sleeve-seal system.
      1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

3. Concrete Slabs-on-Grade:
   a. Piping Smaller Than NPS 6: Cast-iron wall sleeves with sleeve-seal system.
      1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
   b. Piping NPS 6 and Larger: Cast-iron wall sleeves with sleeve-seal system.
      1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

4. Concrete Slabs above Grade:
   b. Piping NPS 6 and Larger: PVC-pipe sleeves.
SECTION 22 05 18 - ESCUTCHEONS FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 SUMMARY
   A. Section Includes:
      1. Escutcheons.
      2. Floor plates.

1.2 ACTION SUBMITTALS
   A. Product Data: For each type of product indicated.

PART 2 - PRODUCTS

2.1 ESCUTCHEONS
   A. One-Piece, Cast-Brass Type: With polished, chrome-plated finish and setscrew fastener.
   B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with chrome-plated finish and spring-clip fasteners.
   C. One-Piece, Stamped-Steel Type: With chrome-plated finish and spring-clip fasteners.

2.2 FLOOR PLATES
   A. One-Piece Floor Plates: Cast-iron flange with holes for fasteners.

PART 3 - EXECUTION

3.1 INSTALLATION
   A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.
   B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.
      1. Escutcheons for New Piping:
         a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
         b. Chrome-Plated Piping: One-piece, cast-brass type with polished, chrome-plated finish.
         c. Insulated Piping: One-piece, stamped-steel type.
d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished, chrome-plated finish.

e. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type.

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

g. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, stamped-steel type.

h. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass type with polished, chrome-plated finish.

i. Bare Piping in Unfinished Service Spaces: One-piece, stamped-steel type.

j. Bare Piping in Equipment Rooms: One-piece, cast-brass type with polished, chrome-plated finish.

k. Bare Piping in Equipment Rooms: One-piece, stamped-steel type.

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

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

1. New Piping: One-piece, floor-plate type.

3.2 FIELD QUALITY CONTROL

A. Replace broken and damaged escutcheons and floor plates using new materials.

END OF SECTION 22 05 18
SECTION 22 05 19 - METERS AND GAGES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Bimetallic-actuated thermometers.
2. Liquid-in-glass thermometers.
3. Thermowells.
4. Dial-type pressure gages.
5. Gage attachments.

1.2 ACTION SUBMITTALS

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

1.3 INFORMATIONAL SUBMITTALS

A. Product certificates.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 BIMETALLIC-ACTUATED THERMOMETERS

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

1. Ashcroft Inc.
2. Ernst Flow Industries.
3. Marsh Bellofram.
8. REOTEMP Instrument Corporation.
10. Trerice, H. O. Co.
11. Watts; a Watts Water Technologies company.
12. Weiss Instruments, Inc.
13. Weksler Glass Thermometer Corp.
14. WIKA Instrument Corporation.
15. Winters Instruments - U.S.


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

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

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

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

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

H. Window: Plain glass.

I. Ring: Stainless steel.

J. Element: Bimetal coil.

K. Pointer: Dark-colored metal.

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

2.2 LIQUID-IN-GLASS THERMOMETERS

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

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   
   a. Flo Fab inc.
   b. Miljoco Corporation.
   d. Tel-Tru Manufacturing Company.
   e. Trrice, H. O. Co.
   f. Weiss Instruments, Inc.
   g. Weksler Glass Thermometer Corp.
   h. Winters Instruments - U.S.


3. Case: Cast aluminum; 7-inch nominal size unless otherwise indicated.

4. Case Form: Adjustable angle unless otherwise indicated.

5. Tube: Glass with magnifying lens and blue or red organic liquid.

6. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F.

7. Window: Glass.

8. Stem: Aluminum and of length to suit installation.

   a. Design for Thermowell Installation: Bare stem.

10. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

2.3 THERMOWELLS

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

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

2.4 PRESSURE GAGES

A. Direct-Mounted and remote mounted, Metal-Case, Dial-Type Pressure Gages:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. AMETEK, Inc.
      b. Ashcroft Inc.
      c. Ernst Flow Industries.
      d. Flo Fab inc.
      e. Marsh Bellofram.
      f. Miljoco Corporation.
      g. Noshok.
      h. Palmer Wahl Instrumentation Group.
      i. REOTEMP Instrument Corporation.
      j. Tel-Tru Manufacturing Company.
      k. Tetrice, H. O. Co.
      l. Watts; a Watts Water Technologies company.
      m. Weiss Instruments, Inc.
      n. Weksler Glass Thermometer Corp.
      o. WIKA Instrument Corporation.
      p. Winters Instruments - U.S.
   3. Case: Liquid-filled type(s); cast aluminum or drawn steel; 4-1/2-inch nominal diameter.
   4. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
   5. Pressure Connection: Brass, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
   6. Movement: Mechanical, with link to pressure element and connection to pointer.
   7. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi.
10. Ring: Metal.
11. Accuracy: Grade B, plus or minus 2 percent of middle half of scale range.

2.5 GAGE ATTACHMENTS

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

B. Valves: Brass ball, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install thermowells with socket extending one-third of pipe diameter and in vertical position in piping tees.

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

C. Install thermowells with extension on insulated piping.

D. Fill thermowells with heat-transfer medium.

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

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

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

H. Install remote-mounted pressure gages on panel.

I. Install valve and snubber in piping for each pressure gage for fluids.

J. Install thermometers in the following locations:

1. Inlet and outlet of each water heater.
2. Inlets and outlets of each domestic water heat exchanger.
3. Inlet and outlet of each domestic hot-water storage tank.
4. Inlet and outlet of each remote domestic water chiller.

K. Install pressure gages in the following locations:

1. Building water service entrance into building.
2. Inlet and outlet of each pressure-reducing valve.
3. Suction and discharge of each domestic water pump.
L. Install meters and gages adjacent to machines and equipment to allow service and maintenance of meters, gages, machines, and equipment.

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

3.2 THERMOMETER SCHEDULE

A. Thermometers at inlet and outlet of each domestic water heater shall be the following:
   1. Industrial-style, liquid-in-glass type.

B. Thermometers at inlets and outlets of each domestic water heat exchanger shall be the following:
   1. Industrial-style, liquid-in-glass type.

C. Thermometers at inlet and outlet of each domestic hot-water storage tank shall be the following:
   1. Industrial-style, liquid-in-glass type.

D. Thermometers at inlet and outlet of each remote domestic water chiller shall be the following:
   1. Industrial-style, liquid-in-glass type.

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

3.3 THERMOMETER SCALE-RANGE SCHEDULE

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

B. Scale Range for Domestic Hot-Water Piping: 20 to 240 deg F.

C. Scale Range for Domestic Cooled-Water Piping: 0 to 100 deg F.

3.4 PRESSURE-GAGE SCHEDULE

A. Pressure gages at discharge of each water service into building shall be the following:
   1. Liquid-filled, direct-mounted, metal case.

B. Pressure gages at inlet and outlet of each water pressure-reducing valve shall be the following:
   1. Liquid-filled, direct-mounted, metal case.

C. Pressure gages at suction and discharge of each domestic water pump shall be the following:
   1. Liquid-filled, direct-mounted, metal case.

3.5 PRESSURE-GAGE SCALE-RANGE SCHEDULE

A. Scale Range for Water Service Piping: 0 to 100 psi.
B. Scale Range for Domestic Water Piping: 0 to 100 psi. 

END OF SECTION 22 05 19
SECTION 22 05 23.12 - BALL VALVES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Brass ball valves.
2. Bronze ball valves.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of valve.

1. Certification that products comply with NSF 61.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

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

B. All piping, valves, and equipment for domestic water use shall comply with the reduction of lead in Drinking Water Act of 2011 which will be enforced January 4, 2014.

C. ASME Compliance:

1. ASME B1.20.1 for threads for threaded end valves.
2. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
4. ASME B31.9 for building services piping valves.

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

E. Bronze valves shall be made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are not permitted.

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

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

H. Valve Actuator Types:

1. Gear Actuator: For quarter-turn valves NPS 4 and larger.
2. Handlever: For quarter-turn valves smaller than NPS 4.
I. Valves in Insulated Piping:
   1. Include 2-inch stem extensions.
   2. Extended operating handles of nonthermal-conductive material and protective sleeves that allow operation of valves without breaking vapor seals or disturbing insulation.
   3. Memory stops that are fully adjustable after insulation is applied.

2.2 BRASS BALL VALVES

A. One-Piece, Brass Ball Valves:
   1. Manufacturers: Subject to compliance with requirements, provide products by the following:
      a. KITZ Corporation.

B. Two-Piece, Brass Ball Valves with Full Port and Brass Trim:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. American Valve, Inc.
      b. Conbraco Industries, Inc.
      c. Crane; Crane Energy Flow Solutions.
      d. DynaQuip Controls.
      e. Hammond Valve.
      f. Jomar Valve.
      g. KITZ Corporation.
      h. Legend Valve.
      i. Marwin Valve; Richards Industries.
      j. Milwaukee Valve Company.
      k. NIBCO INC.
      l. Red-White Valve Corporation.
      m. Stockham; Crane Energy Flow Solutions.
      n. Watts; a Watts Water Technologies company.

2. Description:
   b. CWP Rating: 600 psig.
   c. Body Design: Two piece.
   d. Body Material: Forged brass.
e. Ends: Threaded and soldered.
f. Seats: PTFE.
g. Stem: Brass.
h. Ball: Chrome-plated brass.
i. Port: Full.

C. Two-Piece, Brass Ball Valves with Regular Port and Brass Trim:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Hammond Valve.
   b. Legend Valve.
   c. Milwaukee Valve Company.
   d. NIBCO INC.
   e. Watts; a Watts Water Technologies company.

2. Description:
   b. CWP Rating: 600 psig.
   c. Body Design: Two piece.
   d. Body Material: Forged brass.
   e. Ends: Threaded and soldered.
   f. Seats: PTFE.
   g. Stem: Brass.
   h. Ball: Chrome-plated brass.
   i. Port: Regular.

2.3 BRONZE BALL VALVES

A. One-Piece, Bronze Ball Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Conbraco Industries, Inc.
   b. NIBCO INC.
   c. Watts; a Watts Water Technologies company.

2. Description:
   b. CWP Rating: 400 psig.
   c. Body Design: One piece.
   d. Body Material: Bronze.
   e. Ends: Threaded.
   f. Seats: PTFE.
   g. Stem: Bronze.
   h. Ball: Chrome-plated brass.
   i. Port: Reduced.

B. Two-Piece, Bronze Ball Valves with Full Port, and Bronze or Brass Trim:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Conbraco Industries, Inc.
   b. Crane; Crane Energy Flow Solutions.
   c. Hammond Valve.
   d. Lance Valves.
   e. Milwaukee Valve Company.
   f. NIBCO INC.
   g. Watts; a Watts Water Technologies company.

2. Description:
   b. CWP Rating: 600 psig.
   c. Body Design: Two piece.
   d. Body Material: Bronze.
   e. Ends: Threaded and soldered.
   f. Seats: PTFE.
   g. Stem: Bronze or brass.
   h. Ball: Chrome-plated brass.
   i. Port: Full.

C. Two-Piece, Bronze Ball Valves with Regular Port and Bronze or Brass Trim:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Conbraco Industries, Inc.
   b. DynaQuip Controls.
   c. Hammond Valve.
   d. Milwaukee Valve Company.
   e. NIBCO INC.
   f. Watts; a Watts Water Technologies company.

2. Description:
   b. CWP Rating: 600 psig.
   c. Body Design: Two piece.
   d. Body Material: Bronze.
   e. Ends: Threaded.
   f. Seats: PTFE.
   g. Stem: Bronze or brass.
   h. Ball: Chrome-plated brass.
   i. Port: Regular.
PART 3 - EXECUTION

3.1 VALVE INSTALLATION

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

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

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

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

E. Locate valves above accessible ceilings. If this is not possible, provide

3.2 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. If valves with specified CWP ratings are unavailable, the same types of valves with higher CWP ratings may be substituted.

B. Select valves with the following end connections:

1. For Copper Tubing, NPS 2 and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules below.
2. For Steel Piping, NPS 2 and Smaller: Threaded ends.

3.3 LOW-PRESSURE, COMPRESSED-AIR VALVE SCHEDULE (150 PSIG OR LESS)

A. Pipe NPS 2 and Smaller:

1. Bronze and Brass Valves: May be provided with solder-joint ends instead of threaded ends.
2. One piece, brass ball valve.
3. One piece, bronze ball valve with bronze trim.
4. Two-piece, brass ball valves with full port and brass trim.
5. Two-piece, bronze ball valves with full port and bronze or brass trim.

3.4 HIGH-PRESSURE, COMPRESSED-AIR VALVE SCHEDULE (150 TO 200 PSIG)

A. Pipe NPS 2 and Smaller:

1. Bronze and Brass Valves: May be provided with solder-joint ends instead of threaded ends.
2. One piece, brass ball valve.
3. One piece, bronze ball valve with bronze trim.
4. Two-piece, brass ball valves with full port and brass trim.
5. Two-piece, bronze ball valves with full port and bronze or brass trim.

3.5 DOMESTIC HOT- AND COLD-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller:
1. Bronze and Brass Valves: May be provided with solder-joint ends instead of threaded ends.
2. One piece, brass ball valve.
3. One piece, bronze ball valve with bronze trim.
4. Two-piece, brass ball valves with full port and brass trim.
5. Two-piece, bronze ball valves with full port and bronze or brass trim.

END OF SECTION 22 05 23.12
SECTION 22 05 23.14 - CHECK VALVES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Bronze swing check valves.
2. Iron swing check valves.
3. Iron swing check valves with closure control.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of valve.

1. Certification that products comply with NSF 61.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

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

B. ASME Compliance:

1. ASME B1.20.1 for threads for threaded end valves.
2. ASME B16.1 for flanges on iron valves.
3. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
4. ASME B16.18 for solder joint.
5. ASME B31.9 for building services piping valves.

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

D. Bronze valves shall be made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are not permitted.

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

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

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

2.2 BRONZE SWING CHECK VALVES

A. Class 125, Bronze Swing Check Valves with Bronze Disc:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. American Valve, Inc.
   b. Crane; Crane Energy Flow Solutions.
   c. Hammond Valve.
   d. NIBCO INC.
   e. Red-White Valve Corporation.
   f. Watts; a Watts Water Technologies company.

2. Description:
   a. Standard: MSS SP-80, Type 3.
   b. CWP Rating: 200 psig.
   c. Body Design: Horizontal flow.
   e. Ends: Threaded or soldered. See valve schedule articles.
   f. Disc: Bronze.

B. Class 125, Bronze Swing Check Valves with Nonmetallic Disc:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Crane; Crane Energy Flow Solutions.
   b. Hammond Valve.
   c. NIBCO INC.
   d. Red-White Valve Corporation.
   e. Watts; a Watts Water Technologies company.

2. Description:
   a. Standard: MSS SP-80, Type 4.
   b. CWP Rating: 200 psig.
   c. Body Design: Horizontal flow.
   e. Ends: Threaded or soldered. See valve schedule articles.
   f. Disc: PTFE.

2.3 IRON SWING CHECK VALVES

A. Class 125, Iron Swing Check Valves with Metal Seats:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Crane; Crane Energy Flow Solutions.
   b. Hammond Valve.
   c. NIBCO INC.
   d. Red-White Valve Corporation.
   e. Watts; a Watts Water Technologies company.

2. Description:
a. Standard: MSS SP-71, Type I.
b. CWP Rating: 200 psig.
c. Body Design: Clear or full waterway.
d. Body Material: ASTM A 126, gray iron with bolted bonnet.
e. Ends: Flanged or threaded. See valve schedule articles.
f. Trim: Bronze.
g. Gasket: Asbestos free.

B. Class 125, Iron Swing Check Valves with Nonmetallic-to-Metal Seats:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Crane; Crane Energy Flow Solutions.
   b. Stockham; Crane Energy Flow Solutions.

2. Description:
   a. Standard: MSS SP-71, Type I.
   b. CWP Rating: 200 psig.
   c. Body Design: Clear or full waterway.
   d. Body Material: ASTM A 126, gray iron with bolted bonnet.
   e. Ends: Flanged or threaded. See valve schedule articles.
   f. Trim: Composition.
   g. Seat Ring: Bronze.
   h. Disc Holder: Bronze.
   i. Disc: PTFE.
   j. Gasket: Asbestos free.

2.4 IRON SWING CHECK VALVES WITH CLOSURE CONTROL

A. Class 125, Iron Swing Check Valves with Lever- and Spring-Closure Control:

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

2. Description:
   a. Standard: MSS SP-71, Type I.
   b. CWP Rating: 200 psig.
   c. Body Design: Clear or full waterway.
   d. Body Material: ASTM A 126, gray iron with bolted bonnet.
   e. Ends: Flanged or threaded. See valve schedule articles.
   f. Trim: Bronze.
   g. Gasket: Asbestos free.
   h. Closure Control: Factory-installed exterior lever and spring.

B. Class 125, Iron Swing Check Valves with Lever and Weight-Closure Control:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Crane; Crane Energy Flow Solutions.
b. Hammond Valve.
c. NIBCO INC.
d. Watts; a Watts Water Technologies company.

2. Description:
   a. Standard: MSS SP-71, Type I.
   b. CWP Rating: 200 psig.
   c. Body Design: Clear or full waterway.
   d. Body Material: ASTM A 126, gray iron with bolted bonnet.
   e. Ends: Flanged or threaded. See valve schedule articles.
   f. Trim: Bronze.
   g. Gasket: Asbestos free.
   h. Closure Control: Factory-installed exterior lever and weight.

PART 3 - EXECUTION

3.1 VALVE INSTALLATION
   A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
   B. Locate valves for easy access and provide separate support where necessary.
   C. Install valves in horizontal piping with stem at or above center of pipe.
   D. Install valves in position to allow full stem movement.
   E. Install swing check valves for proper direction of flow in horizontal position with hinge pin level.
   F. Provide check valves at the discharge of each pump.

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

3.3 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS
   A. If valve applications are not indicated, use the following:
      1. Pump-Discharge Check Valves:
         a. NPS 2 and Smaller: Bronze swing check valves with bronze or nonmetallic disc.
         b. NPS 2-1/2 and Larger for Domestic Water: Iron swing check valves with lever and weight or spring; metal-seat or resilient-seat check valves.
         c. NPS 2-1/2 and Larger for Sanitary Waste and Storm Drainage: Iron swing check valves with lever and weight or spring.
B. If valves with specified CWP ratings are unavailable, the same types of valves with higher CWP ratings may be substituted.

C. End Connections:

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

3.4 LOW-PRESSURE, COMPRESSED-AIR VALVE SCHEDULE (150 PSIG OR LESS)

A. Pipe NPS 2 and Smaller:

1. Horizontal and Vertical Applications: Bronze swing check valves, Class 125, nonmetallic disc with soldered or threaded end connections.

B. Pipe NPS 2-1/2 and Larger:

1. Iron swing check valves, Class 125, metal seats with threaded or flanged end connections.

3.5 HIGH-PRESSURE, COMPRESSED-AIR VALVE SCHEDULE (150 TO 200 PSIG)

A. Pipe NPS 2 and Smaller:

1. Horizontal and Vertical Applications: Bronze swing check valves, Class 125, nonmetallic disc with soldered or threaded end connections.

B. Pipe NPS 2-1/2 and Larger:

1. Iron swing check valves, Class 125, metal seats with threaded or flanged end connections.

3.6 DOMESTIC HOT- AND COLD-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller: Bronze swing check valves, Class 125, bronze disc with soldered or threaded end connections.

B. Pipe NPS 2-1/2 and Larger:

1. Iron swing check valves, Class 125, metal seats with threaded or flanged end connections.
2. Iron swing check valves with closure control, Class 125, lever and spring with threaded or flanged end connections.

END OF SECTION 22 05 23.14
PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Bronze gate valves.
2. Iron gate valves.
3. Chainwheels.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of valve.

1. Certification that products comply with NSF 61 and NSF 372.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

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

B. ASME Compliance:

1. ASME B1.20.1 for threads for threaded end valves.
2. ASME B16.1 for flanges on iron valves.
3. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
4. ASME B16.18 for solder joint.
5. ASME B31.9 for building services piping valves.

C. NSF Compliance: NSF 61 and NSF 372 for valve materials for potable-water service.

D. Bronze valves shall be made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are not permitted.

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

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

G. RS Valves in Insulated Piping: With 2-inch stem extensions.

H. Valve Bypass and Drain Connections: MSS SP-45.
2.2 BRONZE GATE VALVES

A. Class 125, NRS, Bronze Gate Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. American Valve, Inc.
   b. Crane; Crane Energy Flow Solutions.
   c. Hammond Valve.
   d. Jenkins Valves; Crane Energy Flow Solutions.
   e. KITZ Corporation.
   f. Macomb Groups (The).
   g. Milwaukee Valve Company.
   h. NIBCO INC.
   i. Powell Valves.
   j. Red-White Valve Corporation.
   k. Stockham; Crane Energy Flow Solutions.
   l. Watts; a Watts Water Technologies company.

2. Description:
   a. Standard: MSS SP-80, Type 1.
   b. CWP Rating: 200 psig.
   d. Ends: Threaded or solder joint.
   e. Stem: Bronze.
   f. Disc: Solid wedge; bronze.
   g. Packing: Asbestos free.
   h. Handwheel: Malleable iron, bronze, or aluminum.

B. Class 125, RS, Bronze Gate Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. American Valve, Inc.
   b. Crane; Crane Energy Flow Solutions.
   c. Hammond Valve.
   d. Jenkins Valves; Crane Energy Flow Solutions.
   e. KITZ Corporation.
   f. Macomb Groups (The).
   g. Milwaukee Valve Company.
   h. NIBCO INC.
   i. Powell Valves.
   j. Stockham; Crane Energy Flow Solutions.
   k. Watts; a Watts Water Technologies company.

2. Description:
   a. Standard: MSS SP-80, Type 2.
   b. CWP Rating: 200 psig.
   d. Ends: Threaded or solder joint.
   e. Stem: Bronze.
f. Disc: Solid wedge; bronze.
g. Packing: Asbestos free.
h. Handwheel: Malleable iron, bronze, or aluminum.

2.3 IRON GATE VALVES

A. Class 125, NRS, Iron Gate Valves:

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

a. Crane; Crane Energy Flow Solutions.
b. Flo Fab inc.
c. Hammond Valve.
d. Jenkins Valves; Crane Energy Flow Solutions.
e. KITZ Corporation.
f. Legend Valve.
g. Macomb Groups (The).
h. Milwaukee Valve Company.
i. NIBCO INC.
j. Powell Valves.
k. Red-White Valve Corporation.
l. Stockham; Crane Energy Flow Solutions.
m. Watts; a Watts Water Technologies company.
n. Zurn Industries, LLC.

2. Description:

a. Standard: MSS SP-70, Type I.
b. CWP Rating: 200 psig.
c. Body Material: Gray iron with bolted bonnet.
d. Ends: Flanged.
e. Trim: Bronze.
f. Disc: Solid wedge.
g. Packing and Gasket: Asbestos free.

B. Class 125, OS&Y, Iron Gate Valves:

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

a. Crane; Crane Energy Flow Solutions.
b. Flo Fab inc.
c. Hammond Valve.
d. Jenkins Valves; Crane Energy Flow Solutions.
e. KITZ Corporation.
f. Legend Valve.
g. Macomb Groups (The).
h. Milwaukee Valve Company.
i. NIBCO INC.
j. Powell Valves.
k. Red-White Valve Corporation.
l. Stockham; Crane Energy Flow Solutions.
m. Watts; a Watts Water Technologies company.
2. Description:
   a. Standard: MSS SP-70, Type I.
   b. CWP Rating: 200 psig.
   c. Body Material: Gray iron with bolted bonnet.
   d. Ends: Flanged.
   e. Trim: Bronze.
   f. Disc: Solid wedge.
   g. Packing and Gasket: Asbestos free.

2.4 CHAINWHEELS
   A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1. Babbitt Steam Specialty Co.
      2. Roto Hammer Industries.
      3. Trumbull Industries.
   B. Description: Valve actuation assembly with sprocket rim, chain guides, chain, and attachment brackets for mounting chainwheels directly to hand wheels.
      1. Sprocket Rim with Chain Guides: Ductile iron, of type and size required for valve. Include zinc or epoxy coating.
      2. Chain: Hot-dip galvanized steel of size required to fit sprocket rim.

PART 3 - EXECUTION

3.1 VALVE INSTALLATION
   A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
   B. Locate valves for easy access and provide separate support where necessary.
   C. Install valves in horizontal piping with stem at or above center of pipe.
   D. Install valves in position to allow full stem movement.
   E. Install chainwheels on operators for gate valves NPS 4 and larger and more than 96 inches above floor. Extend chains to 60 inches above finished floor.

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

3.3 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS
   A. Use gate valves for shutoff service only.
B. If valves with specified CWP ratings are unavailable, the same types of valves with higher CWP ratings may be substituted.

3.4 DOMESTIC HOT- AND COLD-WATER VALVE SCHEDULE

A. Pipe NPS 2-1/2 and Larger: Iron gate valves, Class 125, OS&Y with flanged ends.

END OF SECTION 22 05 23.15
PART 1 - GENERAL

1.1 SUMMARY
A. Section Includes:
   1. Metal pipe hangers and supports.
   2. Trapeze pipe hangers.
   3. Thermal-hanger shield inserts.
   4. Fastener systems.
   5. Pipe positioning systems.
   6. Equipment supports.

1.2 PERFORMANCE REQUIREMENTS
A. Structural Performance: Hangers and supports for plumbing piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.
   1. Design supports for multiple pipes capable of supporting combined weight of supported systems, system contents, and test water.
   2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
   3. Design seismic-restraint hangers and supports for piping and equipment.

1.3 ACTION SUBMITTALS
A. Product Data: For each type of product indicated.
B. Shop Drawings: Show fabrication and installation details and include calculations for the following; include Product Data for components:
   1. Trapeze pipe hangers.
   2. Equipment supports.

1.4 INFORMATIONAL SUBMITTALS
A. Welding certificates.

1.5 QUALITY ASSURANCE
A. Structural Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
PART 2 - PRODUCTS

2.1 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:
   1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
   2. Galvanized Metallic Coatings: Pregalvanized or hot dipped.
   3. Nonmetallic Coatings: Plastic coating, jacket, or liner.
   4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.

B. Stainless-Steel Pipe Hangers and Supports:
   1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
   2. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.

C. Copper Pipe Hangers:
   1. Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.

2.2 TRAPEZE PIPE HANGERS

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

2.3 THERMAL-HANGER SHIELD INSERTS

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

B. Insulation-Insert Material for Hot Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate with 100-psig minimum compressive strength.

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

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

E. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.
2.4 FASTENER SYSTEMS

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

B. Mechanical-Expansion Anchors: Insert-wedge-type, stainless-steel anchors, for use in hardened portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

2.5 PIPE POSITIONING SYSTEMS

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

2.6 EQUIPMENT SUPPORTS

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

2.7 MISCELLANEOUS MATERIALS

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

B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.

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

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT INSTALLATION

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

B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.

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

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

D. Fastener System Installation:
1. Install 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.

E. Pipe Positioning-System Installation: Install support devices to make rigid supply and waste piping connections to each plumbing fixture.

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


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

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

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

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

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

M. Insulated Piping:

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

2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

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

A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.
B. Grouting: Place grout under supports for equipment and make bearing surface smooth.
C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.3 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.
B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.
C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:
   1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
   2. Obtain fusion without undercut or overlap.
   3. Remove welding flux immediately.
   4. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.4 ADJUSTING

A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.
B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

3.5 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
   1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.
B. Touchup: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Section 099123 "Interior Painting."

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

3.6 HANGER AND SUPPORT SCHEDULE

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

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

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

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

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

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

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

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

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

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

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30.
2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 deg F, pipes NPS 4 to NPS 24, requiring up to 4 inches of insulation.
3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36, requiring clamp flexibility and up to 4 inches of insulation.
4. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
5. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30.
6. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
7. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
8. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30, from two rods if longitudinal movement caused by expansion and contraction might occur.
9. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
K. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

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

L. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.

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

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.
7. 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.
8. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
9. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.

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

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

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

1. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
2. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41, roll hanger with springs.
3. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.
P. Comply with MSS SP-69 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.

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

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

END OF SECTION 22 05 29
SECTION 22 05 48 - VIBRATION AND SEISMIC CONTROLS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Isolation pads.
2. Isolation mounts.
3. Restrained elastomeric isolation mounts.
4. Freestanding and restrained spring isolators.
5. Housed spring mounts.
6. Elastomeric hangers.
7. Spring hangers.
8. Spring hangers with vertical-limit stops.
9. Pipe riser resilient supports.
10. Resilient pipe guides.
11. Restraining braces and cables.

1.2 PERFORMANCE REQUIREMENTS

A. Seismic-Restraint Loading:

1. Soil Site Class as Defined in the IBC: D.
2. Seismic Design Category: D
3. Assigned Seismic Use Group or Building Category as Defined in the IBC: III.
   a. Component Importance Factor 1.5 shall be applied to the following systems
      1) Steam Piping and equipment.
   b. a Component Importance Factor of 1.0 shall be applied to the following systems:
      1) All components unless listed for Importance factor of 1.5.

4. Design Spectral Response Acceleration at Short Periods (0.2 Second): 0.59%.
5. Design Spectral Response Acceleration at 1-Second Period: 0.28%.

1.3 DESCRIPTION

A. The work in this section consists of furnishing engineering and materials necessary for vibration isolation and seismic restraints for equipment contained herein for the project.

B. Other sections of DIVISION 22 and 23 form a part of this section. Refer to all sections for a complete description of the work.
C. All mechanical equipment .75 HP and over listed in the equipment schedule shall be mounted on vibration isolators to prevent the transmission of objectionable vibration and vibration induced sound to the building structure.

D. All isolation materials, flexible connectors and seismic restraints shall be selected and certified using published or factory certified data. Any variance or non-compliance with these specification requirements shall be corrected by the contractor in an approved manner.

E. The contractor and manufacturer of the isolation and seismic equipment shall refer to the isolator and seismic restraint schedule which lists isolator types, isolator deflections and seismic restraint type. Vibration isolators shall be selected in accordance with the equipment, pipe or duct weight distribution so as to produce reasonably uniform deflections.

F. Install full line size flexible pipe connectors at the inlet and outlet of each pump, chiller, coiling connections and where shown on the drawings. All connectors shall be suitable for use at the temperature, pressure, and service encountered at the point of installation and operation. End fitting connectors shall conform to the pipefitting schedule. Control rods or protective braid must be used to limit elongation to 3/8". Flexible connectors shall not be required for suspended in-line pumps.

G. Unless otherwise specified, all mechanical, electrical, and plumbing equipment, pipe, and duct shall be restrained to resist seismic forces per the IBC and ASCE 7-05. Restraints shall maintain equipment, piping, and duct work in a captive position. Restraint devices shall be designed and selected to meet the seismic requirements as defined in the latest issue of the IBC or local jurisdiction building code.

1.4 Seismic restraint is NOT required to be applied to the following:

1.5 These requirements are per the International Building Code which references ASCE 7. Contractor to obtain a copy of this document BEFORE BIDDING to ensure all requirements are understood and thereafter to keep it on the job site for reference. Herein is a summary of the seismic bracing exceptions:

A. Seismic Design Category B: All mechanical and electrical components

B. Seismic Design Category C: All mechanical and electrical components with Importance factor of Ip=1.0.

C. Rigidly floor mounted mechanical, electrical, and plumbing components in all seismic design categories, where \( \text{Ip} = 1.0 \) and flexible connections between the components and associated duct work, piping and conduit are provided, that are mounted at 4 feet (1219 mm) or less above a floor level and weight 400 pounds (1780 N) or less and are not critical to the continued operation of the structure. Suspended, wall mounted and flexibly mounted equipment are not included in this exclusion.

D. Hanging, wall mounted, and flexibly supported mechanical, plumbing and electrical components that weigh 20 pounds (89 N) or less, where \( \text{Ip} = 1.0 \) and flexible connections are provided between the components and associated duct work, piping and conduit.

E. Piping supported by individual clevis hangers where the distance, as measured from the top of the pipe to the supporting structure, is less than 12 inches (305mm) for the entire pipe run and the pipe can accommodate the expected deflections. Trapeze or double rod hangers where the distance from the top of the trapeze or support to the structure is less than 12 inches for the entire run. Hanger rods shall not be constructed in a manner that would subject the rod to bending moments (swivel, eye bolt, or vibration isolation hanger connection to structure.)
F. High deformability piping (steel, copper, aluminum with welded, brazed, ground, or screwed connections); provisions are made to avoid impact with larger piping or mechanical components or to protect piping in the event of such impact; and the following size requirements are met:

1. Seismic Class C: where Ip=1.5 and a nominal pipe size of 2” or less.
2. Seismic Class D, E, F: having an Ip=1.0 and a nominal pipe size of 3 inch or less.
3. Seismic Class D, E, F: having an Ip = 1.5 and a nominal pipe size of 1 inch (25 mm) or less where provisions are made to protect the piping from impact or to avoid the impact of larger piping or other mechanical equipment. Note, any combination of piping supported on a trapeze where the total weight exceeds 10 lb/ ft. must be braced.

G. PVC or other plastic or fiberglass vent piping.

H. HVAC ducts with an suspended from hangers that are 12 inches (305 mm) or less in length from the top of the duct to the supporting structure and the hangers are detailed to avoid significant bending of the hangers and their connections. Duct must be positively attached to hanger with minimum #10 screws within 2” from the top of the duct.

I. HVAC ducts that have a cross sectional area of less than 6 square feet (0.557 m2).

J. Equipment items installed in-line with the duct system (e.g, fans, heat exchangers and humidifiers) with an operating weight less than 76 pounds (334 N). Equipment must be rigidly attached to duct at inlet and outlet.

1.6 MANUFACTURER'S RESPONSIBILITIES: Manufacturer of vibration and seismic control products shall have the following responsibilities:

A. Determine vibration isolation and seismic restraint sizes and locations.

B. Provide piping, ductwork and equipment isolation systems and seismic restraints as scheduled or specified.

C. Provide installation instructions and shop drawings for all materials supplied under this section of the specifications.

D. Provide calculations to determine restraint loads resulting from seismic forces presented in the IBC, Chapter 16 latest edition. Seismic calculations shall be certified by a licensed engineer in the employ of the seismic equipment manufacturer with a minimum 5 years experience. Provide calculations for all floor or roof mounted equipment 400lbs (1780 N) or greater (20lbs (89 N)or greater for Ip=1.5), all suspended or wall mounted equipment 20lbs (89 N)or greater, and vibration isolated equipment 20lbs (89 N)or greater.

E. Seismic restraint load ratings must be certified and substantiated by testing or calculations under direct control of a registered professional engineer.

F. Calculations and restraint device submittal drawings shall specify anchor bolt type, embedment, concrete compressive strength, minimum spacing between anchors, and minimum distances of anchors from concrete edges. Concrete anchor locations shall not be near edges, stress joints, or an existing fracture. All bolts shall be ASTM A307 or better.
1.7 QUALITY CONTROL

A. The isolators and seismic restraint systems listed herein are as manufactured by Amber / Booth. Approved equals that meet the requirements of the specifications, are acceptable.

B. Steel components shall be cleaned and painted with industrial enamel. All nuts, bolts and washers shall be zinc-electroplated. Structural steel bases shall be thoroughly cleaned of welding slag and primed with zinc-chromate or metal etching primer.

C. All isolators, bases and seismic restraints exposed to the weather shall utilize cadmium-plated, epoxy coat or PVC coated springs and hot dipped galvanized steel components. Nuts, bolts and washers may be zinc-electroplated. Isolators for outdoor mounted equipment shall provide adequate restraint for the greater of either wind loads required by local codes or withstand a minimum of 30 lb. / sq. ft. applied to any exposed surface of the equipment.

D. Provide a written quality control procedure that outlines complete compliance of attachment of cabling restraints to brackets. For swaged connections, provide a gage to verify swage. For screw/clamp connection, provide torque values for attachment fasteners.

1.8 SUBMITTALS

A. Product Data: For each product indicated.

B. Delegated-Design Submittal: For vibration isolation and seismic-restraint calculations and details indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

C. Welding certificates.

D. Qualification Data: For professional engineer.

E. Field quality-control test reports.

F. Submit shop drawings of all isolators, seismic restraints and calculations provided.

G. The manufacturer of vibration isolation products shall submit the following data for each piece of isolated equipment: clearly identified equipment tag, quantity and size of vibration isolators and seismic restraints for each piece of rotating isolated equipment. Submittals for mountings and hangers incorporating springs shall include spring diameter and free height, rated deflections, and solid load. Submittals for bases shall clearly identify locations for all mountings as well as all locations for attachment points of the equipment to the mounting base. Submittals shall include seismic calculations signed and checked by a qualified licensed engineer in the employ of the manufacturer of the vibration isolators. Catalog cut sheets and installation instructions shall be included for each type of isolation mounting or seismic restraint used on equipment being isolated.

H. Submit quality assurance procedures as required at time of isolator/seismic submittals. Submittal must be stamped by a registered professional engineer who is responsible for the seismic restraint design. All vibration isolation/seismic submittals not complying with this certification will be rejected.

I. Provide shop drawings indicating location of all specification SC cable restraints required for pipe and ductwork. Drawings must be stamped by manufacturer’s registered professional engineer.
J. Mechanical, electrical and plumbing equipment manufacturers shall provide certification that their equipment is capable of resisting expected seismic loads without failure. Equipment manufacturers shall provide suitable attachment points and/or instructions for attaching seismic restraints.

K. Provide a certification from the seismic design engineer that the seismic restraints will comply with the applicable code requirements. Certification must be stamped by a registered profession engineer.

L. Provide a Certificate of Completion from the manufacturer’s representative upon completion of the job.

PART 2 - PRODUCTS

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

1. Ace Mountings Co., Inc.
2. Amber/Booth Company, Inc.
4. Isolation Technology, Inc.
7. Vibration Eliminator Co., Inc.
8. Vibration Isolation.

2.2 VIBRATION ISOLATORS:

A. Specification W: a pad type mounting consisting of two layers of ribbed elastomeric pads with a ½” poro-elastic vibration absorptive material bonded between them. Pads shall be sized for approximate deflection of 0.10” to 0.18”. Pads shall be Amber/Booth Type NRC (or equal).

B. Specification A: an elastomeric mounting having a steel baseplate with mounting holes and a threaded insert at top of the mounting for attaching equipment. All metal parts shall be completely embedded in the elastomeric material. Mountings shall be designed for approximately 1/2” deflection, and incorporate a steel seismic snubber with all directional restraint. Mountings shall be Amber/Booth Type SRVD (or equal).

C. Specification B: an adjustable, freestanding, open spring mounting with combination leveling and equipment fastening bolt. The spring shall be welded to the spring mounting baseplate and compression plate for stability. The isolator shall be designed for a minimum kx/ky (horizontal-to-vertical spring rate) of 1.0. An elastomeric pad having a minimum thickness of 1/4” shall be bonded to the baseplate. Nuts, adjusting bolts and washers shall be zinc-electroplated to prevent corrosion. This type isolator must be used with specification SL seismic restraint (section 2.3.1). Isolators shall be Amber/Booth Type SW (or equal).

D. Specification C: a unitized adjustable, stable open spring isolator with a seismic restraint housing which serves as a blocking device during equipment installation. The spring package shall include an elastomeric pad for high frequency absorption at the base of the spring. The springs shall be designed for a minimum kx/ky (horizontal-to-vertical spring rate) of 1.0. Nuts, adjusting bolts and washers shall be zinc-electroplated to prevent corrosion. The spring assembly shall be removable with equipment in place and shall fit within a welded steel enclosure consisting of a top plate and rigid lower housing. Isolated seismic restraint bolts shall connect top plate to lower housing to resist seismic and wind forces
in all directions and limit motion to a maximum of 1/4” movement before engaging. Surfaces that engage under seismic motion shall be cushioned with a resilient elastomeric pad or grommet to protect equipment. Top plate shall have adequate means for fastening to the equipment, and baseplate shall have adequate means for bolting to structure. Entire assembly shall be rated to exceed the applied seismic load (para 1.3.4.). Seismic isolator shall be Amber/Booth Type CTER (or equal).

E. Specification D: an elastomeric hanger consisting of a rectangular steel box capable of 200% minimum overload without visible deformation, 30 degree rod misalignment and an elastomeric isolation element designed for approximately 1/2” deflection. Hangers shall be Amber/Booth Type BRD (or equal).

F. Specification E: a combination spring and elastomeric hanger consisting of a rectangular steel box capable of 200% minimum overload without visible deformation, 30 degree rod misalignment, coil spring, spring retainers and elastomeric element designed for approximately 1/2” deflection. The spring shall be designed for a minimum kx/ky (horizontal-to-vertical spring rate) of 1.0. Spring hangers shall be Amber/Booth Type BSRA (or equal).

G. Specification F: a set (two or more) of spring thrust resisting assemblies, which consist of coil springs, spring retainer, isolation washer, angle mounting brackets, and elastomeric tubing for isolating thrust resister rod from fan discharge. Thrust restraints shall be Amber / Booth Type TRK (or equal).

H. Specification SB: a unitized adjustable open spring isolator and a welded steel housing designed to resist seismic forces in all directions. Restraint surfaces which engage under seismic motion shall be cushioned with a resilient elastomer to protect equipment. Restraints shall allow a maximum of 1/4” movement before engaging and shall allow for the spring to be changed if required. Isolator shall be a stable spring with a minimum ky/ky of 1.0. The spring package shall include an elastomeric pad for high frequency absorption at the base of the spring. Nuts and bolts shall be zinc-electroplated to prevent corrosion. Bolting equipment to isolator with bolts smaller than main adjusting bolt will not be allowed. Base plate shall provide means for bolting to the structure. Entire assembly shall be rated to exceed the applied seismic load (para 1.3.4.) Mountings shall be Amber/Booth Type SWSR (or equal).

2.3 BASES

A. Specification G: a welded integral structural steel fan and motor base with NEMA standard motor slide rails and holes drilled to receive the fan and motor slide rails. The steel members shall be adequately sized to prevent distortion and misalignment of the drive, and specifically, shall be sized to limit deflection of the beam on the drive side to 0.05” due to starting torque. Snubbers to prevent excessive motion on starting or stopping shall be furnished if required; however, the snubbers shall not be engaged under steady running conditions. Bases shall be Amber/Booth Type SFB (or equal).

B. Specification H: a welded WF (main member) structural steel base for increasing rigidity of equipment mounted thereon or for unitizing belt driven fans. Fan bases shall have holes drilled to match fan and located to provide required center distance between fan and supplied NEMA standard motor slide rails. The steel members shall have minimum depth of 1/12” of the longest span, but not less than 6” deep. Junior beams and junior channels shall not be used. Cross members shall be provided where necessary to support the equipment or to prevent twisting of the main members. Where height restrictions prevent the use of members having a depth of 1/12 of the longest span, beams of less depth may be used provided they have equal rigidity. Provide height-saving brackets for side mounting of the isolators. Brackets for use with Specification type B isolators having 2.5” deflection or greater shall be of the precompression type to limit exposed bolt length. Bases shall be Amber/Booth Type WSB (or equal).

2.4 SEISMIC RESTRAINTS:

A. Specification SL: a restraint assembly for floor mounted equipment consisting of welded steel interlocking assemblies welded or bolted securely to the equipment or the equipment bases and to the supporting structure. Restraint assembly surfaces which engage under seismic motion shall be lined with a minimum ¼" thick resilient elastomeric pad to protect equipment. Restraints shall be field adjustable and be positioned for 1/4" clearance as required to prevent interference during normal operation. Restraint assembly shall have minimum rating of 2 times the catalog rating at 1 G as certified by independent laboratory test. Restraint shall be Amber/Booth Type ER (or equal).

B. Specification SC: a restraint assembly for suspended equipment, piping or ductwork consisting of high strength galvanized steel aircraft cable. Cable must have Underwriters Laboratories listed certified break strength, and shall be color-coded for easy field verification. Secure cable to structure and to braced component through bracket or stake eye specifically designed to exceed cable restraint rated capacity. Cable must be manufactured to meet or exceed minimum materials and standard requirements per AISI Manual for structural applications of steel cables and ASTM A603. Break strengths must be per ASTM E-8 procedures. Safety factor of 1.5 may be used when prestretched cable is used with end connections designed to meet the cable break strength. Otherwise safety factor 3.76 must be used. Cables shall be sized for a force as listed in section 1.3. Cables shall be installed to prevent excessive seismic motion and so arranged that they do not engage during normal operation. Restraint shall be type LRC (or equal).

2.5 ROOFTOP UNIT CURBS AND ISOLATION SYSTEMS

A. Specification W: Non-isolated seismically rated rooftop curb system that is flashed into roofing membrane. Air and watertight curb shall have a neoprene sponge seal at the top and be rigid enough to provide continuous perimeter support for rooftop unit. Curb must provide means to positively anchor to concrete deck, or bolt or weld directly to structural steel to withstand seismic loading. Curb shall provide a means by which contractor supplied insulation may be installed for thermal insulation and acoustic attenuation. Curb shall accommodate roof pitch shown on drawings. Curb shall use minimum 16 gage galvanized steel and shall be designed with crossbracing required to withstand the greater of seismic forces (para 1.3.4.) or wind loading per local building code. Design must be certified by registered professional engineer in the employ of the manufacturer. Seismic curbs shall be Amber/Booth Type RTC (or equal).

B. Specification X: An extruded aluminum rail base for roof top air conditioning units consisting of top and bottom weatherproofed aluminum rails for mounting between equipment and roof curb, incorporating wind/seismic restraints and a continuous air and water seal which is protected from accidental puncture and direct sunlight by an aluminum weather shield. Rails shall incorporate free standing, open spring isolators (minimum kx/kv of 1.0) properly spaced and sized around perimeter for the deflection listed in the isolation schedule. To prevent leaks, rails shall be factory assembled (to the limits of freight carriers) and shipped as a one-piece unit. Where spliced, corners to be factory assembled. Specification X rails may only be used where wind/seismic restraint are capable of withstanding seismic deflection or greater shall be of the pre-compression type to limit exposed bolt length. The perimeter steel members shall have a minimum depth of 1/12 of the longest span, but not less than 6" deep. The base shall be sized with a minimum overlap of 4" around the base of the equipment and, in the case of belt-driven equipment, 4" beyond the end of the drive shaft. Fan bases are to be supplied with NEMA standard motor slide rails. The bases for pumps shall be sized to support the suction elbow of end suction pumps and both the suction and discharge elbows of horizontal split-case pumps. The bases shall be T-shaped where necessary to conserve space. Inertia bases shall be Amber/Booth Type CPF (or equal).
forces per paragraph 1.3.4. Seismic design of the curb supporting the isolation rail shall be provided by the roof curb manufacturer. Rails shall be Amber/Booth Type RTIR (or equal).

C. Specification Y: Seismically rated rooftop isolation curb system that is flashed into roofing membrane. Standard unit curb will not be used. Air and watertight upper curb shall have a neoprene sponge seal at the top and be rigid enough provide continuous perimeter support for rooftop unit. The upper curb shall be supported by type C isolators welded or bolted to continuous structural support which is positively anchored to concrete deck or bolted or welded to the structure to withstand seismic loading. An EPDM nylon reinforced airtight weatherproof seal shall consolidate the upper and lower curbs. Weatherproof access doors shall be provided at each isolator to allow isolator adjustment. Isolation curb shall provide a means by which contractor supplied insulation may be installed for thermal insulation and acoustic attenuation. Curbs shall accommodate roof pitch shown on drawings. Isolation curb shall use minimum 16 gage galvanized steel and shall be designed with crossbracing required to withstand the greater of seismic forces (para 1.3.4.) or wind loading per local building code. Design must be certified by registered professional engineer in the employ of the manufacturer. Isolation curbs shall be Amber/Booth Type RTIC (or equal).

2.6 FLEXIBLE PIPE CONNECTIONS

A. Specification K:

1. Water Service: For flanged connection – a double sphere arch rubber expansion joint constructed of molded reinforced neoprene with integral steel floating flanges, and designed to be suitable for pressures up to 225 PSI (4 to 1 safety factor) and temperatures up to 225 °F. Connectors shall have minimum movement capabilities of 1.77” compression, 1.18” lateral and 1.18” extension. Connectors shall provide a minimum 35° angular movement up to 6”, minimum 30° up to 12” and minimum 20° up to 24”. Spring-loaded control units shall be furnished to limit movement to within allowables. Amber/Booth Type 2600 (or equal).

2. Water Service: For threaded type – A double spherical rubber hose connector, minimum 8” long, constructed of molded neoprene, nylon cord reinforced, with female pipe unions each end. Connectors shall have a minimum movement capability of 7/8” compression, 7/8” lateral, 1/4” extension and 20° angular through 1-1/4”, 13° through 2”, and 9° through 3”. Connectors shall be suitable for a maximum working pressure (4 to 1 safety factor) of 150 psi and 225 degree F. Connectors shall have cable control units to limit extension to 1/4”. Amber/Booth Type 2655 (or equal).

B. Specification L: Steam and Condensate Service:

1. For flanged connection – a metal hose connector constructed of stainless steel hose and braid with carbon steel plate flanges. Live lengths shall conform to hose minimum length to absorb thermal and dynamic movement. Hose axis must be perpendicular to pipe movement. Amber/Booth Type SS-FP or SS-FW (or equal).

2. For threaded connections - a metal hose connector constructed of stainless steel hose and braid with carbon steel NPT threaded end fittings. Minimum lengths shall conform to the following (Amber/Booth Type SS-PM (or equal).

a. 1-1/2” dia. (and smaller) x 10” long
b. 2” x 12”
c. 2-1/2” x 13”
d. 3” x 14”
e. 3-1/2” x 16”
f. 4” x 16”

C. Air Compressor Service
1. For flanged connection – a flanged metal hose connector constructed of stainless steel hose and braid with carbon steel plate flanges. Connector shall be double braided with a minimum live length equal to four times the diameter. Connector shall be installed with the long axis perpendicular to the motion to be absorbed. Amber/Booth Type SS-FP (Special) (or equal).

2. For threaded connection – a metal hose connector constructed of stainless steel hose and braid with carbon steel NPT threaded end fittings. Connector shall be double braided and have a minimum live length equal to four times the diameter. Connector shall be installed with the long axis perpendicular to the motion to be absorbed. Amber/Booth Type SS-PM (special) (or equal).

2.7 PIPE GUIDES AND ANCHORS FOR ISOLATED PIPING

A. Specification M: For Pipe Guides where specifically shown on drawings to accommodate expansion loops and compensators, the vibration isolator manufacturer shall provide pipe guides consisting of a telescopic arrangement of two sizes of steel tubing separated by a minimum, half inch thickness of heavy duty neoprene and duck or elastomeric isolation material. Guides shall be Amber/Booth type AG (or equal).

B. Specification N: For anchors where specifically shown on drawings to accommodate expansion loops and compensators, the vibration isolator manufacturer shall provide all directional acoustical pipe anchors consisting of a telescopic arrangement of two sizes of steel tubing separated by a minimum half inch thickness of heavy duty neoprene and duck or elastomeric isolation material. All-directional anchors shall be Amber/Booth type AG (or equal).

PART 3 - EXECUTION

3.1 Isolator and seismic restraints shall be installed as recommended by the manufacturer. Isolate all mechanical equipment 0.75 hp and over per the isolation schedule and these specifications.

3.2 PIPING ISOLATION

A. Horizontal Pipe Isolation: all HVAC pumped water, pumped condensate, glycol, and refrigerant piping size 1-1/4” and larger within mechanical rooms shall be isolated. Outside equipment rooms this piping shall be isolated for the greater of 50’ or 100 pipe diameters from rotating equipment. For the first 3 support locations from externally isolated equipment provide specification E hangers or specification SB or SX floor mounts with the same deflection as equipment isolators (max 2”). All other piping within the equipment rooms shall be isolated with the same specification isolators with a 3/4” minimum deflection. Steam piping size 1-1/4” and larger which is within an equipment room and connected to rotating equipment shall be isolated for three (3) support locations from the equipment. Provide specification E or SB (SX) isolators with the same deflection as the equipment but a minimum of 3/4”.

B. All plumbing pumped water, pumped condensate, and steam piping size 1-1/4” and larger within mechanical rooms shall be isolated the same as HVAC piping (para. 3.2-A). Isolators are not required for any plumbing pumped water, pumped condensate, and steam piping outside of mechanical rooms unless listed in the isolation schedule.

C. Pipe Riser Isolation: All variable temperature vertical pipe risers 1-1/4” and larger, riser piping requiring isolation per para. 3.2-A or 3.2-B or where specifically shown and detailed on riser drawings shall be fully supported by specification B mounts with precompression plates. Steel spring deflection shall be 3/4-inch minimum except in those locations where added deflection is required due to pipe expansion and contraction. Spring deflection shall be a minimum of 4 times the anticipated deflection change.
Springs shall be selected to keep the riser in tension. Pipe risers up through 16" shall be supported at intervals of every third floor of the building. Pipe risers 18" and over, every second floor. Wall sleeves for take-offs from riser shall be sized for insulation O.D. plus two times the anticipated movement to prevent binding. Horizontal take-offs and at upper and lower elbows shall be supported with spring isolators as required to accommodate anticipated movement. In addition to submittal data requirements previously outlined, riser diagrams and calculations shall be submitted for approval. Calculations must show anticipated expansion and contraction at each support point, initial and final loads on the building structure, and spring deflection changes. Submittal data shall include certification that the riser system has been examined for excessive stresses and that none will exist if installed per design proposed. Riser supports shall be Amber/Booth Type SWP.

3.3 DUCT ISOLATION:

A. Isolate all duct work with a static pressure 2" W.C. and over in equipment rooms and to minimum of 50 feet from the fan or air handler. Use specification type E hangers or type SB (SX) floor mounts.

3.4 INSTALLATION

A. Comply with manufacturer’s instructions for the installation and load application of vibration isolation materials and products. Adjust to ensure that units do not exceed rated operating deflections or bottom out under loading, and are not short-circuited by other contacts or bearing points. Remove space blocks and similar devices (if any) intended for temporary support during installation or shipping.

B. Locate isolation hangers as near the overhead support structure as possible.

C. Adjust leveling devices as required to distribute loading uniformly on isolators. Shim units as required where leveling devices cannot be used to distribute loading properly.

D. Install isolated inertia base frames and steel bases on isolator units as indicated so that a minimum of 2 inch clearance below base will result when supported equipment has been installed and loaded for operation.

E. Roof curbs shall be installed directly to building structural steel or concrete roof deck. Installation on top of steel deck or roofing material is not acceptable.

3.5 APPLICATION OF SEISMIC RESTRAINTS

A. ISOLATED EQUIPMENT

1. All floor mounted isolated equipment shall be protected with type SB or type C unitized isolator and restraint or with separate type SL restraints (minimum of 4) in conjunction with type B isolators. For equipment with high center of gravity additional cable restraints shall be furnished, as required by isolation manufacturer, to limit forces and motion caused by rocking.

2. All suspended isolated equipment and vessels shall be protected with specification SC restraints. Cables shall be installed to prevent excessive seismic motion and so arranged that they do not engage during normal operation.

B. RIGIDLY MOUNTED EQUIPMENT
1. Floor mounted which are not exempt shall be protected by properly sized anchor bolts with elastomeric grommets provided by the isolation manufacturer. Suspended equipment shall be protected with type SC bracing.

C. PIPING

1. All piping shall be protected in all planes by SC restraints, designed to accommodate thermal movement as well as restrain seismic motion. (Spring-loaded control rods should be used on flexible connectors in system). Tanks and vessels connected inline to piping shall be restrained independently. Locations shall be as determined by the isolator/seismic restraint supplier and shall include, but not be limited to:

   a. At a proximity to protect all drops to equipment connections.
   b. At changes in direction of pipe as required to limit over stressing of pipe or movement that contacts other building material.
   c. At horizontal runs of pipe, not to exceed the spacing as presented in SMACNA design criteria.
   d. SMACNA design criteria. Seismic restraints shall not be required for piping exempted by previous specification sections.
   e. Where riser pipes pass through cored holes, core diameters to be a maximum of 2” larger than pipe O.D. including insulation. Cored holes must be packed with resilient material or firestop as provided by other sections of this specification or local codes. No additional horizontal seismic bracing is required. Restrained isolators type C or SB shall support risers and provide longitudinal restraint at floors where thermal expansion is minimal and will not bind isolator restraints. For risers in pipe shafts, specification SC cable restraints shall be installed at each level in a manner that does not interfere with thermal movement.

D. Piping Restraints:

1. Comply with requirements in MSS SP-127.
2. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.
3. Brace a change of direction longer than 12 feet.

E. Install cables so they do not bend across edges of adjacent equipment or building structure.

F. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction providing required submittals for component.

G. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.

H. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

I. Drilled-in Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Set anchors to manufacturer’s recommended torque, using a torque wrench.
5. Install zinc-coated steel anchors for interior and stainless steel anchors for exterior applications.

J. DUCT WORK

1. Duct work 6 square feet and larger in cross sectional area shall be protected in all planes by SC restraints. Locations shall be determined by the isolator supplier and shall include, but not be limited to:
   a. At equipment connections as required to protect the connections.
   b. At all duct runs and duct run ends (transverse bracing and longitudinal bracing not to exceed spacing specified in SMACNA guidelines).

2. The isolation and/or seismic restraints listed shall be furnished and installed for the equipment listed in the vibration Control and Seismic Restraint device schedule table below in accordance with the previous sections of this specification:

3.6 APPLICATIONS

A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an agency acceptable to authorities having jurisdiction.

B. Hanger Rod Stiffeners: Install hanger rod stiffeners where required to prevent buckling of hanger rods due to seismic forces.

C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits.

3.7 VIBRATION-CONTROL AND SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Equipment Restraints:
   1. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inches.
   2. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction providing required submittals for component.

3.8 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Install flexible connections in piping where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment. Comply with requirements in Division 22 Section "Domestic Water Piping" for piping flexible connections.
3.9 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:
   1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
   2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.
   4. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
   5. Test to 90 percent of rated proof load of device.
   7. Measure isolator deflection.
   8. If a device fails test, modify all installations of same type and retest until satisfactory results are achieved.

C. Remove and replace malfunctioning units and retest as specified above.

D. Prepare test and inspection reports.

3.10 ADJUSTING

A. Adjust isolators after piping system is at operating weight.

B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

C. Adjust active height of spring isolators.

D. Adjust restraints to permit free movement of equipment within normal mode of operation.
### VIBRATION-CONTROL AND SEISMIC-RESTRAINT DEVICE SCHEDULE

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Importance Factor</th>
<th>Location</th>
<th>Application</th>
<th>Isolation Required</th>
<th>Anchor Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Heater Storage Tank</td>
<td>1.0</td>
<td>Basement</td>
<td>Floor Mounted</td>
<td>None</td>
<td>Specification SL (Amber Booth Type ER or equal) and SC</td>
</tr>
<tr>
<td>Air Compressor</td>
<td>1.0</td>
<td>Basement</td>
<td>Floor Mounted</td>
<td>3/4” deflection</td>
<td>Specification SB (Amber/Booth SWSR or equal) See under “Isolation Required”</td>
</tr>
<tr>
<td>ET-1, 2, 3, 4, 5, PET-1</td>
<td>1.0</td>
<td>Basement</td>
<td>Floor Mounted</td>
<td>None</td>
<td>Anchor Bolts with Elastomeric Grommets</td>
</tr>
<tr>
<td>Heat Pumps - floor mounted</td>
<td>1.0</td>
<td>Varies</td>
<td>Floor Mounted</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Suspended Heat Pumps</td>
<td>1.0</td>
<td>Varies</td>
<td>Suspended</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Buffer Tank BT-1, 2</td>
<td>1.0</td>
<td>Basement</td>
<td>Floor Mounted</td>
<td>None</td>
<td>Anchor Bolts with Elastomeric Grommets and Specification SC (Amber Booth Type LRC or equal)</td>
</tr>
<tr>
<td>AGF-1, 2</td>
<td>1.0</td>
<td>Basement</td>
<td>Floor Mounted</td>
<td>None</td>
<td>Anchor Bolts with Elastomeric Grommets</td>
</tr>
<tr>
<td>Cabinet unit heaters</td>
<td>1.0</td>
<td>Various</td>
<td>Suspended</td>
<td>None</td>
<td>Specification SC (Amber Booth Type LRC or equal)</td>
</tr>
<tr>
<td>Pump P-HW1, HW2, P-GS1, P-GS2, P-HP1, P-HP2</td>
<td>1.0</td>
<td>Basement</td>
<td>Floor Mounted</td>
<td>Specification W (Amber/Booth Type NRC or equal). See Drawings for Detail</td>
<td>Specification SL (Amber Booth Type ER or equal)</td>
</tr>
<tr>
<td>DOAS-1, AHU-1, ECON-1</td>
<td>1.0</td>
<td>4th floor mezzanine</td>
<td>Floor Mounted</td>
<td>Internal Spring Isolators per AHU Specification</td>
<td>Specification SL (Amber Booth Type ER or equal)</td>
</tr>
<tr>
<td>DWH-1 Domestic water heat pump</td>
<td>1.0</td>
<td>Basement</td>
<td>Floor Mounted</td>
<td>None</td>
<td>Anchor Bolts</td>
</tr>
<tr>
<td>Air Separator AS-1, AS-2, AS-3</td>
<td>1.0</td>
<td>Basement</td>
<td>Suspended</td>
<td>None</td>
<td>Specification SC (Amber Booth Type LRC or equal)</td>
</tr>
<tr>
<td>Suspended Centrifugal fans up to 15 hp</td>
<td>1.0</td>
<td>Varies</td>
<td>Suspended</td>
<td>3/4” deflection Specification SB (Amber/Booth SWSR or equal)</td>
<td>Specification SC (Amber Booth Type LRC or equal)</td>
</tr>
<tr>
<td>Utility Set Fans</td>
<td>1.0</td>
<td>Varies</td>
<td>Roof Mounted</td>
<td>3/4” deflection</td>
<td>Specification SB (Amber/Booth SWSR or equal) See under &quot;Isolation Required&quot;</td>
</tr>
<tr>
<td>Steam to HW Heat Exchangers HX-1, HX-2</td>
<td>1.5</td>
<td>Basement</td>
<td>Floor Mounted on welded frame</td>
<td>None</td>
<td>Anchor Bolts</td>
</tr>
<tr>
<td>Unit Heaters</td>
<td>1.0</td>
<td>Various</td>
<td>Suspended</td>
<td>None</td>
<td>Specification SC (Amber Booth Type LRC or equal)</td>
</tr>
<tr>
<td>Duct mounted components &gt;76 lbs (airflow valves, humidifiers, heating coils, VAV boxes, etc.)</td>
<td>1.0</td>
<td>Varies</td>
<td>Suspended</td>
<td>None</td>
<td>Specification SC (Amber Booth Type LRC or equal)</td>
</tr>
<tr>
<td>Equipment</td>
<td>Importance Factor</td>
<td>Location</td>
<td>Application</td>
<td>Isolation Required</td>
<td>Anchor Type</td>
</tr>
<tr>
<td>----------------------------</td>
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<td>---------------------------------------------------------</td>
<td>------------------------------------------</td>
</tr>
<tr>
<td>Piping and Ductwork</td>
<td>1.0</td>
<td>Varies</td>
<td>Suspended</td>
<td>See requirements within this specification section</td>
<td>See requirements within this specification section</td>
</tr>
<tr>
<td>Condensate pump</td>
<td>1.0</td>
<td>Basement</td>
<td>Floor Mounted</td>
<td>None</td>
<td>Anchor Bolts</td>
</tr>
</tbody>
</table>

END OF SECTION 22 05 48
SECTION 22 05 53 - IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Equipment labels.
2. Warning signs and labels.
3. Pipe labels.

1.2 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Metal Labels for Equipment:

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

   a. Brady Corporation.
   b. Brimar Industries, Inc.
   c. Carlton Industries, LP.
   d. Champion America.
   e. Craftmark Pipe Markers.
   f. emedco.
   g. Kolbi Pipe Marker Co.
   h. LEM Products Inc.
   i. Marking Services, Inc.
   j. Seton Identification Products.

2. Material and Thickness: aluminum, 0.032-inch or anodized aluminum, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.


4. Background Color: Black.

5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.

7. Fasteners: Stainless-steel rivets or self-tapping screws.

8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
B. Plastic Labels for Equipment:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Brady Corporation.
   b. Brimar Industries, Inc.
   c. Carlton Industries, LP.
   d. Champion America.
   e. Craftmark Pipe Markers.
   f. emedco.
   g. Kolbi Pipe Marker Co.
   h. LEM Products Inc.
   i. Marking Services, Inc.
   j. Seton Identification Products.

2. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.
4. Background Color: Black.
5. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
6. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
7. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
9. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

C. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), and the Specification Section number and title where equipment is specified.

D. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number, and identify Drawing numbers where equipment is indicated (plans, details, and schedules) and the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.2 WARNING SIGNS AND LABELS

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

1. Brady Corporation.
2. Brimar Industries, Inc.
3. Carlton Industries, LP.
5. Craftmark Pipe Markers.
6. emedco.
7. LEM Products Inc.
8. Marking Services Inc.
10. Seton Identification Products.
11. Stranco, Inc.
B. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.

C. Letter Color: Yellow.

D. Background Color: Black.

E. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

F. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

G. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.

H. Fasteners: Stainless-steel rivets or self-tapping screws.

I. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

J. Label Content: Include caution and warning information plus emergency notification instructions.

2.3 PIPE LABELS

A. Retain this article if these devices will identify some or all piping. Identification of piping by color-coded painting is covered in "Pipe Label Installation" Article.

B. Do not use pipe labels or plastic tapes for bare pipes conveying fluids at temperatures of 125 deg F (52 deg C) or higher.

C. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Actioncraft Products, Inc.; a division of Industrial Test Equipment Co., Inc.
   2. Brady Corporation.
   4. Carlton Industries, LP.
   5. Champion America.
   7. emedco.
   8. Kolbi Pipe Marker Co.
   9. LEM Products Inc.
  10. Marking Sevices Inc.
  11. Seton Identification Products.

D. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.

E. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.

F. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.
G. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings; also include pipe size and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with piping-system service lettering to accommodate both directions or as separate unit on each pipe label to indicate flow direction.
2. Lettering Size: At least 1/2 inch for viewing distances up to 72 inches and proportionately larger lettering for greater viewing distances.

PART 3 - EXECUTION

3.1 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of mechanical equipment.
B. Locate equipment labels where accessible and visible.

3.2 PIPE LABEL INSTALLATION

A. Pipe Label Locations: Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:

1. Near each valve and control device.
2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations and on both sides of through walls, floors, ceilings, and inaccessible enclosures.
4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 25 feet along each run. Reduce intervals to 15 feet in areas of congested piping and equipment.

B. Pipe Label Color Schedule:

1. Low-Pressure Compressed Air Piping:
   a. Background: Safety blue.
2. High-Pressure Compressed Air Piping:
   a. Background: Safety blue.
3. Domestic Water Piping
   a. Background: Safety green.
4. Sanitary Waste and Storm Drainage Piping:
END OF SECTION 22 05 53
SECTION 22 07 19 - PLUMBING PIPING INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes insulating the following plumbing piping services:
   1. Domestic hot-water piping.
   2. Domestic recirculating hot-water piping.
   3. Sanitary waste piping exposed to freezing conditions.
   4. Storm-water piping exposed to freezing conditions.
   5. Roof drains and rainwater leaders.

B. Related Sections:
   1. Section 22 07 16 "Plumbing Equipment Insulation."

1.2 ACTION SUBMITTALS

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

B. LEED Submittals:
   1. Product Data for Credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content and chemical components.
   2. LEED For Schools: Laboratory Test Reports for Credit IEQ 4: For adhesives and sealants, documentation indicating that product complies with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
   1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
   2. Detail removable insulation at piping specialties, equipment connections, and access panels.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84 by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.
1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

B. Comply with the following applicable standards and other requirements specified for miscellaneous components:


PART 2 - PRODUCTS

2.1 INSULATION MATERIALS


B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
   a. Pittsburgh Corning Corporation.

2. Special-Shaped Insulation: ASTM C 552, Type III.
3. Preformed Pipe Insulation without Jacket: Comply with ASTM C 552, Type II, Class 1.
5. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.

G. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials.

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

1. Aeroflex USA, Inc.
2. Armacell LLC.
3. K-Flex USA.

I. Mineral-Fiber, Preformed Pipe Insulation:
J. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Johns Manville; a Berkshire Hathaway company.
2. Knauf Insulation.
3. Manson Insulation Inc.
4. Owens Corning.
5. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ-SSL. Factory-applied jacket requirements are specified in “Factory-Applied Jackets” Article.

K. Polyolefin: Unicellular, polyethylene thermal plastic insulation. Comply with ASTM C 534 or ASTM C 1427, Type I, Grade 1 for tubular materials.

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

1. Armacell LLC.
2. Nomaco Insulation.

2.2 INSULATING CEMENTS


B. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. Ramco Insulation, Inc.

2.3 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.

B. Cellular-Glass Adhesive: Two-component, thermosetting urethane adhesive containing no flammable solvents, with a service temperature range of minus 100 to plus 200 deg F.

C. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. Foster Brand; H. B. Fuller Construction Products.
2. LEED: For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. LEED for Schools: Adhesive shall comply with the testing and product requirements of the California Department of Health Services’ "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

D. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.

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

1. Aeroflex USA, Inc.
2. Armacell LLC.
3. Foster Brand; H. B. Fuller Construction Products.
4. K-Flex USA.
5. LEED: For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
6. LEED for Schools: Adhesive shall comply with the testing and product requirements of the California Department of Health Services’ "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

F. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

G. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Childers Brand; H. B. Fuller Construction Products.
   2. Eagle Bridges - Marathon Industries.
   3. Foster Brand; H. B. Fuller Construction Products.
   4. Mon-Eco Industries, Inc.
   5. LEED: For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   6. LEED for Schools: Adhesive shall comply with the testing and product requirements of the California Department of Health Services’ "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."


I. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Childers Brand; H. B. Fuller Construction Products.
   2. Eagle Bridges - Marathon Industries.
   3. Foster Brand; H. B. Fuller Construction Products.
   4. Mon-Eco Industries, Inc.
   5. LEED: For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   6. LEED for Schools: Adhesive shall comply with the testing and product requirements of the California Department of Health Services’ "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

J. PVC Jacket Adhesive: Compatible with PVC jacket.

K. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Dow Corning Corporation.
   2. Johns Manville; a Berkshire Hathaway company.
   5. LEED: For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   6. LEED for Schools: Adhesive shall comply with the testing and product requirements of the California Department of Health Services’ "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.4 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.
1. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below-ambient services.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Foster Brand; H. B. Fuller Construction Products.
      b. Vimasco Corporation.
   2. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm at 43-mil dry film thickness.
   3. Service Temperature Range: Minus 20 to plus 180 deg F.
   4. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.

C. Breather Mastic: Water based; suitable for indoor and outdoor use on above-ambient services.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Childers Brand; H. B. Fuller Construction Products.
      b. Eagle Bridges - Marathon Industries.
      c. Foster Brand; H. B. Fuller Construction Products.
      d. Mon-Eco Industries, Inc.
      e. Vimasco Corporation.
   2. Water-Vapor Permeance: ASTM F 1249, 1.8 perms at 0.0625-inch dry film thickness.
   3. Service Temperature Range: Minus 20 to plus 180 deg F.
   4. Solids Content: 60 percent by volume and 66 percent by weight.

2.5 SEALANTS

A. Joint Sealants:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Childers Brand; H. B. Fuller Construction Products.
   2. Eagle Bridges - Marathon Industries.
   3. Foster Brand; H. B. Fuller Construction Products.
   4. Mon-Eco Industries, Inc.
   5. Pittsburgh Corning Corporation.
   6. LEED: For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   7. LEED for Schools: Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. FSK and Metal Jacket Flashing Sealants:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Childers Brand; H. B. Fuller Construction Products.
   b. Eagle Bridges - Marathon Industries.
   c. Foster Brand; H. B. Fuller Construction Products.
   d. Mon-Eco Industries, Inc.

2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F.
5. Color: Aluminum.
6. LEED: For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. LEED for Schools: Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

D. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:
1. Manufacturers: Subject to compliance with requirements, provide products by the following:
   a. Childers Brand; H. B. Fuller Construction Products.

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.
6. LEED: For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. LEED for Schools: Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.6 FACTORY-APPLIED JACKETS
A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
   1. ASJ: 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.

2.7 FIELD-APPLIED FABRIC-REINFORCING MESH
A. Woven Polyester Fabric: Approximately 1 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in., in a Leno weave, for pipe.
B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Foster Brand; H. B. Fuller Construction Products.
2. Vimasco Corporation.

2.8 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

B. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Johns Manville; a Berkshire Hathaway company.
   b. P.I.C. Plastics, Inc.
   c. Proto Corporation.
   d. Speedline Corporation.

2. Adhesive: As recommended by jacket material manufacturer.


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, mechanical joints, and P-trap and supply covers for lavatories.

C. Aluminum Jacket: Comply with ASTM B 209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Childers Brand; H. B. Fuller Construction Products.
   b. ITW Insulation Systems; Illinois Tool Works, Inc.
   c. RPR Products, Inc.

2. Factory cut and rolled to size.

3. Finish and thickness are indicated in field-applied jacket schedules.


5. Moisture Barrier for Outdoor Applications: 3-mil- thick, heat-bonded polyethylene and kraft paper.

6. Factory-Fabricated Fitting Covers:
   a. Same material, finish, and thickness as jacket.
   b. Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
   c. Tee covers.
   d. Flange and union covers.
   e. End caps.
   f. Beveled collars.
   g. Valve covers.
   h. Field fabricate fitting covers only if factory-fabricated fitting covers are not available.
D. Underground Direct-Buried Jacket: 125-mil-thick vapor barrier and waterproofing membrane consisting of a rubberized bituminous resin reinforced with a woven-glass fiber or polyester scrim and laminated aluminum foil.

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

1. Pittsburgh Corning Corporation.
2. Polyguard Products, Inc.

2.9 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Avery Dennison Corporation, Specialty Tapes Division.
   b. Compac Corporation.
   c. Ideal Tape Co., Inc.; an American Biltrite company.
   d. Venture Tape.

2. Width: 3 inches.
3. Thickness: 11.5 mils.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Avery Dennison Corporation, Specialty Tapes Division.
   b. Compac Corporation.
   c. Ideal Tape Co., Inc.; an American Biltrite company.
   d. Venture Tape.

2. Width: 3 inches.
3. Thickness: 6.5 mils.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Compac Corporation.
b. Ideal Tape Co., Inc.; an American Biltrite company.
c. Venture Tape.

2. Width: 2 inches.
3. Thickness: 6 mils.
5. Elongation: 500 percent.
6. Tensile Strength: 18 lbf/inch in width.

D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Avery Dennison Corporation, Specialty Tapes Division.
   b. Compac Corporation.
   c. Ideal Tape Co., Inc.; an American Biltrite company.
   d. Venture Tape.

2. Width: 2 inches.
3. Thickness: 3.7 mils.
5. Elongation: 5 percent.
6. Tensile Strength: 34 lbf/inch in width.

2.10 SECUREMENTS

A. Aluminum Bands: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inch wide with wing seal or closed seal.

B. Manufacturers: Subject to compliance with requirements, provide products by the following:
   1. ITW Insulation Systems; Illinois Tool Works, Inc.
   2. RPR Products, Inc.

C. Staples: Outward-clinching insulation staples, nominal 3/4-inch- wide, stainless steel or Monel.

D. Wire: 0.062-inch soft-annealed, galvanized steel.

E. Manufacturers: Subject to compliance with requirements, provide products by the following:

2.11 PROTECTIVE SHIELDING GUARDS

A. Protective Shielding Pipe Covers:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Engineered Brass Company.
b. Insul-Tect Products Co.
c. McGuire Manufacturing.
d. Plumberex Specialty Products, Inc.
e. Truebro.
f. Zurn Industries, LLC.

2. Description: Manufactured plastic wraps for covering plumbing fixture hot- and cold-water supplies and trap and drain piping. Comply with Americans with Disabilities Act (ADA) requirements.

PART 3 - EXECUTION

3.1 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

B. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

C. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.2 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping including fittings, valves, and specialties.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of pipe system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

G. Keep insulation materials dry during application and finishing.

H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

I. Install insulation with least number of joints practical.

J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.

3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.

4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

L. Install insulation with factory-applied jackets as follows:

   1. Draw jacket tight and smooth.
   2. Cover circumferential joints with 3-inch- wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
   3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 4 inches o.c.

      a. For below-ambient services, apply vapor-barrier mastic over staples.

   4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
   5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.

M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

P. For above-ambient services, do not install insulation to the following:

   1. Vibration-control devices.
   2. Testing agency labels and stamps.
   3. Nameplates and data plates.

3.3 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

   1. Seal penetrations with flashing sealant.
   2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
   3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.

C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
4. Seal jacket to wall flashing with flashing sealant.

D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.

1. Comply with requirements in Section 07 84 13 "Penetration Firestopping" for firestopping and fire-resistant joint sealers.

F. Insulation Installation at Floor Penetrations:

1. Pipe: Install insulation continuously through floor penetrations.
2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 07 84 13 "Penetration Firestopping."

3.4 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 and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.

9. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.

C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

D. Install removable insulation covers at locations indicated. Installation shall conform to the following:

1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.

2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.

3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.

4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.

5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.5 INSTALLATION OF CELLULAR-GLASS INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation to pipe with wire or bands and tighten bands without deforming insulation materials.

2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above-ambient services, secure laps with outward clinched staples at 6 inches o.c.
4. For insulation with factory-applied jackets on below-ambient services, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with 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.

3.6 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

A. Seal longitudinal seams and end joints with manufacturer’s recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

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.

3.7 INSTALLATION OF MINERAL-FIBER PREFORMED PIPE INSULATION

A. Insulation Installation on Straight Pipes and Tubes:
   1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
   2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
   3. For insulation with factory-applied jackets on above-ambient surfaces, secure laps with outward clinched staples at 6 inches o.c.
   4. For insulation with factory-applied jackets on below-ambient surfaces, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:
   1. Install preformed pipe insulation to outer diameter of pipe flange.
   2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
   3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
   4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:
   1. Install preformed sections of same material as straight segments of pipe insulation when available.
   2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:
   1. Install preformed sections of same material as straight segments of pipe insulation when available.
   2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
   3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
   4. Install insulation to flanges as specified for flange insulation application.
3.8 INSTALLATION OF POLYOLEFIN INSULATION

A. Insulation Installation on Straight Pipes and Tubes:
   1. Seal split-tube 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 polyolefin 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 polyolefin 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 cut sections of polyolefin pipe and sheet 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.
   4. Secure insulation to valves and specialties, and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.9 FIELD-APPLIED JACKET INSTALLATION

A. 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.

B. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints. Seal with manufacturer's recommended adhesive.
   1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

C. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant.
recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

3.10 FINISHES

A. Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 09 91 13 "Exterior Painting" and Section 09 91 23 "Interior Painting."

1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.

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.

3.11 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Inspect pipe, fittings, strainers, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three locations of straight pipe, three locations of threaded fittings, three locations of welded fittings, two locations of threaded strainers, two locations of welded strainers, three locations of threaded valves, and locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.

C. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.12 PIPING INSULATION SCHEDULE, GENERAL

A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.

B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:

1. Drainage piping located in crawl spaces.
2. Underground piping.
3. Chrome-plated pipes and fittings unless there is a potential for personnel injury.
3.13 INDOOR PIPING INSULATION SCHEDULE

<table>
<thead>
<tr>
<th>System</th>
<th>Pipe Size and Location</th>
<th>Insulation Type and Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Storm Drainage Piping, Roof Drain and Sumps</td>
<td>Above Ground Piping</td>
<td>½-inch fiberglass insulation with ASJ Vapor Barrier Jacket</td>
</tr>
<tr>
<td>Including overflow and standard drains</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Domestic Hot Water</td>
<td>Piping in Building 1-1/2-inches and smaller</td>
<td>1-inch fiberglass insulation with ASJ Vapor barrier jacket</td>
</tr>
<tr>
<td>Domestic Hot Water</td>
<td>Piping in Building 2 inches and larger</td>
<td>1-1/2 inch fiberglass insulation with ASJ vapor barrier jacket</td>
</tr>
<tr>
<td>Domestic Cold Water and Pure Water</td>
<td>Piping in Building 2-inches and smaller</td>
<td>1-inch fiberglass insulation with ASJ Vapor barrier jacket</td>
</tr>
<tr>
<td>Domestic Cold Water and Pure Water</td>
<td>Piping in Building 2-1/2 inches and larger</td>
<td>1-1/2 inch fiberglass insulation with ASJ vapor barrier jacket</td>
</tr>
<tr>
<td>Domestic Hot Water Recirculation Piping</td>
<td>Piping in Building</td>
<td>1-inch Fiberglass insulation with ASJ Vapor barrier jacket</td>
</tr>
</tbody>
</table>

3.14 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE

A. Sanitary Waste and Storm drain Piping Where Heat Tracing Is Installed: Insulation shall be one of the following:

1. Mineral-Fiber, Preformed Pipe Insulation, Type I: 2 inches thick.

3.15 INDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Piping, Concealed:

1. None.

D. Piping, Exposed:

1. PVC: 20 mils thick. Paintable

3.16 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Piping, Concealed:

1. Aluminum, Smooth: 0.024 inch thick.
D. Piping, Exposed:
   1. Aluminum, Smooth: 0.024 inch thick.

3.17 UNDERGROUND, FIELD-INSTALLED INSULATION JACKET

A. For underground direct-buried piping applications, install underground direct-buried jacket over insulation material.

END OF SECTION 22 07 19
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.
   B. The OPR and BOD documentation are included by reference for information only.

1.2 SUMMARY
   A. This section includes commissioning process requirements for Plumbing systems, assemblies, and equipment.
   B. Related Sections:
      1. Division 01 Section 01 91 13 "General Commissioning Requirements" for general commissioning process requirements.

1.3 DESCRIPTION
   A. Refer to Division 01 Section 01 91 13 “General Commissioning Requirements” for the description of commissioning.

1.4 DEFINITIONS
   A. Refer to Division 01 Section 01 91 13 “General Commissioning Requirements” for definitions.

1.5 SUBMITTALS
   A. Refer to Division 01 Section 01 91 13 “General Commissioning Requirements” for CxA’s role.
   B. Refer to Division 01 Section “Submittals” for specific requirements. In addition, provide the following:
   C. Certificates of readiness
   D. Certificates of completion of installation, prestart, and startup activities.
   E. O&M manuals
   F. Test reports
1.6 QUALITY ASSURANCE

A. Test Equipment Calibration Requirements: Contractors will comply with test manufacturer's calibration procedures and intervals. Recalibrate test instruments immediately after instruments have been repaired resulting from being dropped or damaged. Affix calibration tags to test instruments. Furnish calibration records to CxA upon request.

1.7 COORDINATION

A. Refer to Division 01 Section 01 91 13 “General Commissioning Requirements” for requirements pertaining to coordination during the commissioning process.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. All standard testing equipment required to perform startup, initial checkout and functional performance testing shall be provided by the contractor for the equipment being tested. For example, the plumbing contractor of Division 22 shall ultimately be responsible for all standard testing equipment for the plumbing system in Division 22, except for equipment specific to and used by TAB in their commissioning responsibilities. A sufficient quantity of two-way radios shall be provided by each subcontractor.

B. Special equipment, tools and instruments (specific to a piece of equipment and only available from vendor) required for testing shall be included in the base bid price to the Owner and left on site, except for stand-alone data logging equipment that may be used by the CxA.

C. Proprietary test equipment and software required by any equipment manufacturer for programming and/or start-up, whether specified or not, shall be provided by the manufacturer of the equipment. Manufacturer shall provide the test equipment, demonstrate its use, and assist in the commissioning process as needed. Proprietary test equipment (and software) shall become the property of the Owner upon completion of the commissioning process.

D. Data logging equipment and software required to test equipment will be provided by the CxA, but shall not become the property of the Owner.

E. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified in the Specifications. If not otherwise noted, the following minimum requirements apply: Temperature sensors and digital thermometers shall have a certified calibration within the past year to an accuracy of 0.5°F and a resolution of ±0.1°F. Pressure sensors shall have an accuracy of ± or -2.0% of the value range being measured (not full range of meter) and have been calibrated within the last year.

PART 3 - EXECUTION

3.1 GENERAL DOCUMENTATION REQUIREMENTS

A. With assistance from the installing contractors, the CxA will prepare Pre-Functional Checklists for all commissioned components, equipment, and systems
B. Red-lined Drawings:
   1. The contractor will verify all equipment, systems, instrumentation, wiring and components are shown correctly on red-lined drawings.
   2. Preliminary red-lined drawings must be made available to the Commissioning Team for use prior to the start of Functional Performance Testing.
   3. Changes, as a result of Functional Testing, must be incorporated into the final as-built drawings, which will be created from the red-lined drawings.
   4. The contracted party, as defined in the Contract Documents will create the as-built drawings.

C. Operation and Maintenance Data:
   1. Contractor will provide a copy of O&M literature within 45 days of each submittal acceptance for use during the commissioning process for all commissioned equipment and systems.
   2. The CxA will review the O&M literature once for conformance to project requirements.
   3. The CxA will receive a copy of the final approved O&M literature once corrections have been made by the contractor.

D. Demonstration and Training:
   1. Contractor will provide demonstration and training as required by the specifications.
   2. A complete training plan and schedule must be submitted by the contractor to the CxA four weeks (4) prior to any training.
   3. A training agenda for each training session must be submitted to the CxA one (1) week prior the training session.
   4. The CxA shall be notified at least 72 hours in advance of scheduled tests so that testing may be observed by the CxA and Owner's representative. A copy of the test record shall be provided to the CxA, Owner, and Architect.
   5. Engage a Factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain specific equipment.
   6. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, trouble shooting, servicing, and maintaining equipment.
   7. Review data in O&M Manuals.

E. Systems manual requirements:
   1. The Systems Manual is intended to be a usable information resource containing all of the information related to the systems, assemblies, and Commissioning Process in one place with indexes and cross references.
   2. The GC shall include final approved versions of the following information for the Systems Manual:
      a. As-Built System Schematics
      b. Verified Record Drawings
      c. Test Results (not otherwise included in Cx Record)
      d. Periodic Maintenance Information for computer maintenance management system
      e. Recommendations for recalibration frequency of sensors and actuators
      f. A list of contractors, subcontractors, suppliers, architects, and engineers involved in the project along with their contact information
      g. Training Records, Information on training provided, attendees list, and any on-going training
   3. This information shall be organized and arranged by building system, such as fire alarm, chilled water, heating hot water, etc.
4. Information should be provided in an electronic version to the extent possible. Legible, scanned images are acceptable for non-electronic documentation to facilitate this deliverable.

3.2 CONTRACTOR’S RESPONSIBILITIES

A. Perform commissioning tests at the direction of the CxA.

B. Attend construction phase controls coordination meetings.

C. Attend domestic water balancing review and coordination meetings.

D. Participate in Plumbing systems, assemblies, equipment, and component maintenance orientation and inspection as directed by the CxA.

E. Provide information requested by the CxA for final commissioning documentation.

F. Include requirements for submittal data, operation and maintenance data, and training in each purchase order or sub-contract written.

G. Prepare preliminary schedule for Plumbing system orientations and inspections, operation and maintenance manual submissions, training sessions, pipe and duct system testing, flushing and cleaning, equipment start-up, testing and balancing and task completion for owner. Distribute preliminary schedule to commissioning team members.

H. Update schedule as required throughout the construction period.

I. During the startup and initial checkout process, execute the related portions of the prefunctional checklists for all commissioned equipment.

J. Assist the CxA in all verification and functional performance tests.

K. Provide measuring instruments and logging devices to record test data, and provide data acquisition equipment to record data for the complete range of testing for the required test period.

L. Gather operation and maintenance literature on all equipment, and assemble in binders as required by the specifications. Submit to CxA (45) days after submittal acceptance.

M. Coordinate with the CxA to provide (48) hour advance notice so that the witnessing of equipment and system start-up and testing can begin.

N. Notify the CxA a minimum of (2) weeks in advance of the time for start of the balancing work. Attend the initial balancing meeting for review of the balancing procedures.

O. Participate in, and schedule vendors and contractors to participate in the training sessions.

P. Provide written notification to the CM/GC and CxA that the following work has been completed in accordance with the contract documents, and that the equipment, systems, and sub-system are operating as required.
   1. Plumbing equipment including domestic water heaters, pumps, plumbing fixtures, and all other equipment furnished under this Division.
   2. Gas piping, sanitary waste and vent piping, storm drainage piping, sump pumps and automatic sprinkler system.
3. Fire stopping in fire rated construction, including caulking, gasketing and sealing of smoke barriers.

Q. The equipment supplier shall document the performance of his equipment.

R. Provide a complete set of red-lined drawings to the CxA prior to the start of Functional Performance Testing.

S. Balance Contractor
1. Attend initial commissioning coordination meeting scheduled by the CxA.
2. Submit the site specific balancing plan to the CxA and Design Professional for review and acceptance.
3. Attend the balancing review meeting scheduled by the CxA. Be prepared to discuss the procedures that shall be followed in balancing the Plumbing system.
4. At the completion of the balancing work, and the submittal of the final balancing report, notify the Plumbing contractor and the CM/GC.
5. At the completion of balancing work, and the submittal of the final balancing report, notify the Plumbing Contractor and the CM/GC.
6. Participate in verification of the balancing report, which will consist of repeating measurements contained in the balancing reports. Assist in diagnostic purposes when directed.

T. Provide training of the Owner’s operating staff using expert qualified personnel, as specified.

U. Equipment Suppliers
1. Provide all requested submittal data, including detailed start-up procedures and specific responsibilities of the Owner, to keep warranties in force.
2. Assist in equipment testing per agreements with contractors.
3. Provide information requested by CxA regarding equipment sequence of operation and testing procedures.

V. Refer to Division 01 Section 01 91 13 “General Commissioning Requirements” for additional contractor responsibilities.

3.3 OWNER’S RESPONSIBILITIES
A. Refer to Division 01 Section 01 91 13 “General Commissioning Requirements” for Owner’s Responsibilities.

3.4 DESIGN PROFESSIONAL’S RESPONSIBILITIES
A. Refer to Division 01 Section 01 91 13 “General Commissioning Requirements” for Design Professional’s Responsibilities.

3.5 CxA’S RESPONSIBILITIES
A. Refer to Division 01 Section 01 91 13 “General Commissioning Requirements” for CxA’s Responsibilities.
3.6 TESTING PREPARATION

A. Certify in writing to the CxA that Plumbing systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.

B. Certify in writing to the CxA that Plumbing instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents, and that pretest set points have been recorded.

C. Certify in writing that balancing procedures have been completed and that testing, adjusting, and balancing reports have been submitted, discrepancies corrected, and corrective work approved.

D. Set systems, subsystems, and equipment into operating mode to be tested (e.g., normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).

E. Inspect and verify the position of each device and interlock identified on checklists.

F. Check safety cutouts, alarms, and interlocks with smoke control and life-safety systems during each mode of operation.

G. Testing Instrumentation: Install measuring instruments and logging devices to record test data as directed by the CxA.

3.7 DOMESTIC WATER BALANCING VERIFICATION

A. Prior to performance of Domestic Water Balancing work, provide copies of reports, sample forms, checklists, and certificates to the CxA.

B. Notify the CxA at least ten (10) days in advance of testing and balancing Work, and provide access for the CxA to witness balancing Work.

C. Provide technicians, instrumentation, and tools to verify testing and balancing of Plumbing systems at the direction of the CxA.

   1. The CxA will notify testing and balancing subcontractor ten (10) days in advance of the date of field verification. Notice will not include data points to be verified.
   2. The balancing subcontractor shall use the same instruments (by model and serial number) that were used when original data were collected.
   3. Failure of an item includes a deviation of more than 10 percent. Failure of more than 10 percent of selected items shall result in rejection of final balancing report.
   4. Remedy the deficiency and notify the CxA so verification of failed portions can be performed.

3.8 GENERAL TESTING REQUIREMENTS

A. Provide technicians, instrumentation, and tools to perform commissioning test at the direction of the CxA.

B. Scope of Plumbing testing shall include entire Plumbing installation. Testing shall include measuring capacities and effectiveness of operational and control functions.
C. Test all operating modes, interlocks, control responses, and responses to abnormal or emergency conditions, and verify proper response of building automation system controllers and sensors.

D. The CxA along with the Plumbing contractor, balancing subcontractor shall prepare detailed testing plans, procedures, and checklists for Plumbing systems, subsystems, and equipment.

E. Tests will be performed using design conditions whenever possible.

F. Simulated conditions may need to be imposed using an artificial load when it is not practical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by the CxA and document simulated conditions and methods of simulation. After tests, return settings to normal operating conditions.

G. The CxA may direct that set points be altered when simulating conditions is not practical.

H. The CxA may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are not practical.

I. If tests cannot be completed because of a deficiency outside the scope of the Plumbing system, document the deficiency and report it to the Owner. After deficiencies are resolved, reschedule tests.

J. If the testing plan indicates specific seasonal testing, complete appropriate initial performance tests and documentation and schedule seasonal tests.

3.9 PLUMBING SYSTEMS, SUBSYSTEMS, AND EQUIPMENT TESTING PROCEDURES

A. Equipment Testing and Acceptance Procedures: Testing requirements are specified in individual Division 22 sections. Provide submittals, test data, inspector record, and certifications to the CxA.

B. Plumbing Instrumentation and Control System Testing: Field testing plans and testing requirements are specified in Division 23 Section 23 09 93 "Instrumentation and Control for HVAC" and "Sequence of Operations for HVAC Controls." Assist the CxA with preparation of testing plans.

C. Pipe system cleaning, flushing, hydrostatic tests, and chemical treatment: Test requirements are specified in Division 22 piping Sections. Plumbing Contractor shall prepare a pipe system cleaning, flushing, and hydrostatic testing plan. Provide cleaning, flushing, testing, and treating plan and final reports to the CxA. Plan shall include the following:

1. Sequence of testing and testing procedures for each section of pipe to be tested, identified by pipe zone or sector identification marker. Markers shall be keyed to Drawings for each pipe sector, showing the physical location of each designated pipe test section. Drawings keyed to pipe zones or sectors shall be formatted to allow each section of piping to be physically located and identified when referred to in pipe system cleaning, flushing, hydrostatic testing, and chemical treatment plan.

2. Description of equipment for flushing operations.


4. Tracking checklist for managing and ensuring that all pipe sections have been cleaned, flushed, hydrostatically tested, and chemically treated.

D. Plumbing Distribution System Testing: Provide technicians, instrumentation, tools, and equipment to test performance of air, fuel gas, sanitary waste and vent piping, storm drainage piping, sprinkler and domestic water distribution systems.
E. Vibration and Sound Tests: Provide technicians, instrumentation, tools, and equipment to test performance of vibration isolation and seismic controls.

F. The work included in the commissioning process involves a complete and thorough evaluation of the operation and performance of all components, systems and sub-systems. The following equipment and systems shall be evaluated:

1. Domestic Hot Water System
2. Gas System – Natural Gas
3. Hot Water Circulating Pump
4. Hot Water Tempering Station
5. Plumbing Fixtures

3.10 DEFICIENCIES/NON-CONFORMANCE, COST OF RETESTING, FAILURE DUE TO MANUFACTURER DEFECT

A. Refer to Division 01 Section “General Commissioning Requirements” for requirements pertaining to deficiencies/non-conformance, cost of retesting, or failure due to manufacturer defect.

3.11 APPROVAL

A. Refer to Division 01 Section “General Commissioning Requirements” for approval procedures.

3.12 DEFERRED TESTING

A. Refer to Division 01 Section “General Commissioning Requirements” for requirements pertaining to deferred testing.

3.13 OPERATION AND MAINTENANCE MANUALS

A. The Operation and Maintenance Manuals shall conform to Contract Documents requirements as stated in Division 01.

B. Refer to Division 01 Section “General Commissioning Requirements” for the AE and CxA roles in the Operation and Maintenance Manual contribution, review and approval process.

3.14 TRAINING OF OWNER PERSONNEL

A. Refer to Division 01 Section “General Commissioning Requirements” for requirements pertaining to training.

B. Plumbing Contractor. The mechanical contractor shall have the following training responsibilities:

1. Provide the CxA with a training plan two weeks before the planned training.
2. Provide designated Owner personnel with comprehensive orientation and training in the understanding of the systems and the operation and maintenance of each piece of Plumbing equipment.
3. During any demonstration, should the system fail to perform in accordance with the requirements of the O&M manual or sequence of operations, the system will be repaired or adjusted as necessary and the demonstration repeated.

4. The appropriate trade or manufacturer’s representative shall provide the instructions on each major piece of equipment. This person may be the start-up technician for the piece of equipment, the installing contractor or manufacturer’s representative. Practical building operating expertise as well as in-depth knowledge of all modes of operation of the specific piece of equipment are required. More than one party may be required to execute the training.

5. The training sessions shall follow the outline in the Table of Contents of the operation and maintenance manual and illustrate whenever possible the use of the O&M manuals for reference.

6. Hands-on training shall include start-up, operation in all modes possible, including manual, shut-down and any emergency procedures and preventative maintenance for all pieces of equipment.

7. The plumbing contractor shall fully explain and demonstrate the operation, function and overrides of any local packaged controls.

8. Training shall occur after functional testing is complete, unless approved otherwise by the Owner.

END OF SECTION 22 08 00
SECTON 22 11 13 - FACILITY WATER DISTRIBUTION PIPING

PART 1 - GENERAL

1.1 SUMMARY
   A. This Section includes water-distribution piping and related components outside the building for water service fire-service mains.
   B. Utility-furnished products include water meters that will be furnished to the site, ready for installation.

1.2 ACTION SUBMITTALS
   A. Product Data: For each type of product indicated.
   B. Shop Drawings: Detail precast concrete vault assemblies and indicate dimensions, method of field assembly, and components.

1.3 INFORMATIONAL SUBMITTALS
   A. Field quality-control test reports.

1.4 CLOSEOUT SUBMITTALS
   A. Operation and maintenance data.

1.5 QUALITY ASSURANCE
   A. Regulatory Requirements:
      1. Comply with requirements of utility company supplying water. Include tapping of water mains and backflow prevention.
      2. Comply with standards of authorities having jurisdiction for potable-water-service piping, including materials, installation, testing, and disinfection.
      3. Comply with standards of authorities having jurisdiction for fire-suppression water-service piping, including materials, hose threads, installation, and testing.
   B. Piping materials shall bear label, stamp, or other markings of specified testing agency.
   C. Comply with ASTM F 645 for selection, design, and installation of thermoplastic water piping.
   D. Comply with FMG's "Approval Guide" or UL's "Fire Protection Equipment Directory" for fire-service-main products.
   E. NFPA Compliance: Comply with NFPA 24 for materials, installations, tests, flushing, and valve and hydrant supervision for fire-service-main piping for fire suppression.
F. NSF Compliance:
   1. Comply with NSF 14 for plastic potable-water-service piping.
   2. Comply with NSF 61 for materials for water-service piping and specialties for domestic water.

1.6 COORDINATION
   A. Coordinate connection to water main with utility company.

PART 2 - PRODUCTS

2.1 PIPE AND FITTINGS

A. Soft Copper Tube: ASTM B 88, Type K, water tube, annealed temper.

B. Hard Copper Tube: ASTM B 88, Type K, water tube, drawn temper.

C. Mechanical-Joint, Ductile-Iron Pipe: AWWA C151, with mechanical-joint bell and plain spigot end unless grooved or flanged ends are indicated.
   1. Mechanical-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
   2. Glands, Gaskets, and Bolts: AWWA C111, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

D. Push-on-Joint, Ductile-Iron Pipe: AWWA C151, with push-on-joint bell and plain spigot end unless grooved or flanged ends are indicated.
   1. Push-on-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
   2. Gaskets: AWWA C111, rubber.

E. Grooved-Joint, Ductile-Iron Pipe: AWWA C151, with cut, rounded-grooved ends.
   1. Grooved-End, Ductile-Iron Pipe Appurtenances:

F. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Anvil International; a subsidiary of Mueller Water Products, Inc.
   2. Smith-Cooper International.
   3. Victaulic Company.

G. PVC, AWWA Pipe: AWWA C900, Class 150 and Class 200, with bell end with gasket, and with spigot end.
1. Comply with UL 1285 for fire-service mains if indicated.
2. PVC Fabricated Fittings: AWWA C900, Class 150 and Class 200, with bell-and-spigot or double-bell ends. Include elastomeric gasket in each bell.
3. PVC Molded Fittings: AWWA C907, Class 150, with bell-and-spigot or double-bell ends. Include elastomeric gasket in each bell.
4. Push-on-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
5. Mechanical-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
   a. Glands, Gaskets, and Bolts: AWWA C111, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

2.2 JOINING MATERIALS

A. Refer to Section 33 05 00 "Common Work Results for Utilities" for commonly used joining materials.
B. Brazing Filler Metals: AWS A5.8, BCuP Series.
C. Bonding Adhesive for Fiberglass Piping: As recommended by fiberglass piping manufacturer.
D. Plastic Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.

2.3 PIPING SPECIALTIES

A. Transition Fittings: Manufactured fitting or coupling same size as, with pressure rating at least equal to and ends compatible with, piping to be joined.
B. Tubular-Sleeve Pipe Couplings:
   1. Description: Metal, bolted, sleeve-type, reducing or transition coupling, with center sleeve, gaskets, end rings, and bolt fasteners and with ends of same sizes as piping to be joined.

2.4 GATE VALVES

A. AWWA, Cast-Iron Gate Valves:
B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. American AVK Co.
   3. Crane; Crane Energy Flow Solutions.
   5. McWane, Inc.
7. NIBCO INC.
9. Zurn Industries, LLC.
10. Nonrising-Stem, Metal-Seated Gate Valves:
    a. Description: Gray- or ductile-iron body and bonnet; with cast-iron or bronze double-disc
gate, bronze gate rings, bronze stem, and stem nut.

        1) Standard: AWWA C500.
        2) Minimum Pressure Rating: 200 psig.
        3) End Connections: Mechanical joint.
        4) Interior Coating: Complying with AWWA C550.

11. Nonrising-Stem, Resilient-Seated Gate Valves:
    a. Description: Gray- or ductile-iron body and bonnet; with bronze or gray- or ductile-iron
gate, resilient seats, bronze stem, and stem nut.

        1) Standard: AWWA C509.
        2) Minimum Pressure Rating: 200 psig.
        3) End Connections: Mechanical joint.
        4) Interior Coating: Complying with AWWA C550.

12. Nonrising-Stem, High-Pressure, Resilient-Seated Gate Valves:
    a. Description: Ductile-iron body and bonnet; with bronze or ductile-iron gate, resilient seats,
bronze stem, and stem nut.

        1) Standard: AWWA C509.
        2) Minimum Pressure Rating: 250 psig.
        3) End Connections: Push on or mechanical joint.
        4) Interior Coating: Complying with AWWA C550.

13. OS&Y, Rising-Stem, Metal-Seated Gate Valves:
    a. Description: Cast- or ductile-iron body and bonnet, with cast-iron double disc, bronze disc
and seat rings, and bronze stem.

        1) Standard: AWWA C500.
        2) Minimum Pressure Rating: 200 psig.
        3) End Connections: Flanged.

14. OS&Y, Rising-Stem, Resilient-Seated Gate Valves:
    a. Description: Cast- or ductile-iron body and bonnet, with bronze or gray- or ductile-iron gate,
resilient seats, and bronze stem.

        1) Standard: AWWA C509.
        2) Minimum Pressure Rating: 200 psig.
        3) End Connections: Flanged.

C. UL/FMG, Cast-Iron Gate Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   b. Crane; Crane Energy Flow Solutions.
   c. McWane, Inc.
   d. Mueller Co.
   e. NIBCO INC.
   g. Zurn Industries, LLC.

2. UL/FMG, Nonrising-Stem Gate Valves:
   a. Description: Iron body and bonnet with flange for indicator post, bronze seating material, and inside screw.
      1) Standards: UL 262 and FMG approved.
      2) Minimum Pressure Rating: 175 psig.
      3) End Connections: Flanged.

3. OS&Y, Rising-Stem Gate Valves:
   a. Description: Iron body and bonnet and bronze seating material.
      1) Standards: UL 262 and FMG approved.
      2) Minimum Pressure Rating: 175 psig.
      3) End Connections: Flanged.

D. Bronze Gate Valves:

E. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Crane; Crane Energy Flow Solutions.
   2. Hammond Valve.
   4. NIBCO INC.
   5. Red-White Valve Corporation.
   6. Zurn Industries, LLC.
   7. OS&Y, Rising-Stem Gate Valves:
      a. Description: Bronze body and bonnet and bronze stem.
         1) Standards: UL 262 and FMG approved.
         2) Minimum Pressure Rating: 175 psig.
         3) End Connections: Threaded.

8. Nonrising-Stem Gate Valves:
   a. Description: Class 125, Type 1, bronze with solid wedge, threaded ends, and malleable-iron handwheel.
      1) Standard: MSS SP-80.
2.5 GATE VALVE ACCESSORIES AND SPECIALTIES

A. Tapping-Sleeve Assemblies:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   b. East Jordan Iron Works, Inc.
   c. Flowserve Corporation.
   d. McWane, Inc.
   e. Mueller Co.

2. Description: Sleeve and valve compatible with drilling machine.
   a. Standard: MSS SP-60.
   b. Tapping Sleeve: Cast- or ductile-iron or stainless-steel, two-piece bolted sleeve with flanged outlet for new branch connection. Include sleeve matching size and type of pipe material being tapped and with recessed flange for branch valve.
   c. Valve: AWWA, cast-iron, nonrising-stem, metal-seated gate valve with one raised face flange mating tapping-sleeve flange.

B. Valve Boxes: Comply with AWWA M44 for cast-iron valve boxes. Include top section, adjustable extension of length required for depth of burial of valve, plug with lettering “WATER,” and bottom section with base that fits over valve and with a barrel approximately 5 inches in diameter.

1. Operating Wrenches: Steel, tee-handle with one pointed end, stem of length to operate deepest buried valve, and socket matching valve operating nut.

C. Indicator Posts: UL 789, FMG-approved, vertical-type, cast-iron body with operating wrench, extension rod, and adjustable cast-iron barrel of length required for depth of burial of valve.

2.6 WATER METERS

A. Water meters will be furnished by the mechanical contractor.

B. Manufacturers: Neptune

C. Compound-Type Water Meters: Neptune Tru/Flo with Tricon E3 transmitter to connect to existing MSU Ion metering system.

1. Description:
   b. Registration: Flow in gallons.

2.7 BACKFLOW PREVENTERS

A. Reduced-Pressure-Principle Backflow Preventers: Design Basis Watts 957
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Ames Fire & Waterworks.
   b. Conbraco Industries, Inc.
   c. FEBCO.
   d. Flowmatic Corporation.
   e. Watts; a Watts Water Technologies company.
   f. Wilkins.
   g. Zurn Industries, LLC.

3. Operation: Continuous-pressure applications.
4. Pressure Loss: 12 psig maximum, through middle 1/3 of flow range.
5. Size: 3"
6. Maximum discharge Rate: 300 gpm @70 psi.
8. Selected Unit Flow Range Limits: 150 gpm.
9. Pressure Loss at Design Flow Rate: 12 psig for NPS 2 and smaller; 12 psig for NPS 2-1/2 and larger.
10. Body: Bronze for NPS 2 and smaller; cast iron with interior lining complying with AWWA C550 or that is FDA approved for NPS 2-1/2 and larger.
11. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
12. Configuration: Designed for horizontal, straight through flow.
13. Accessories:
   a. Valves: Ball type with threaded ends on inlet and outlet of NPS 2 and smaller; OS&Y gate type with flanged ends on inlet and outlet of NPS 2-1/2 and larger.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. General: Use pipe, fittings, and joining methods for piping systems according to the following applications.

B. Transition couplings and special fittings with pressure ratings at least equal to piping pressure rating may be used, unless otherwise indicated.

C. Do not use flanges or unions for underground piping.

D. Flanges, unions, and special fittings may be used, instead of joints indicated, on aboveground piping.

E. Aboveground Water-Service Piping NPS 3/4 to NPS 3 shall be hard copper tube, ASTM B 88, Type K; wrought-copper, solder-joint fittings; and brazed joints.

F. Above groundwater-service piping NPS 4 and NPS 6 shall be any of the following:
   1. Hard copper tube, ASTM B 88, Type K; wrought-copper, solder-joint fittings; and brazed joints.
   2. Ductile-iron, grooved-end pipe; ductile-iron, grooved-end appurtenances; and grooved joints.
3.2 VALVE APPLICATIONS

A. General Application: Use mechanical-joint-end valves for NPS 3 and larger underground installation. Use threaded- or flanged-end valves for installation in vaults. Use UL/FMG, nonrising-stem gate valves for installation with indicator posts. Use corporation valves and curb valves with ends compatible with piping, for NPS 2 and smaller installation.

B. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:

1. Use the following for valves in vaults and aboveground:
   a. Gate Valves, NPS 2 and Smaller: Bronze, nonrising stem.
   b. Gate Valves, NPS 3 and Larger: AWWA, cast iron, OS&Y rising stem, resilient seated.

3.3 PIPING SYSTEMS - COMMON REQUIREMENTS

A. See Section 33 05 00 "Common Work Results for Utilities" for piping-system common requirements.

3.4 PIPING INSTALLATION

A. Water-Main Connection: Arrange with utility company for tap of size and in location indicated in water main.

B. Water-Main Connection: Tap water main according to requirements of water utility company and of size and in location indicated.

C. Make connections larger than NPS 2 with tapping machine according to the following:

1. Install tapping sleeve and tapping valve according to MSS SP-60.
2. Install tapping sleeve on pipe to be tapped. Position flanged outlet for gate valve.
3. Use tapping machine compatible with valve and tapping sleeve; cut hole in main. Remove tapping machine and connect water-service piping.
4. Install gate valve onto tapping sleeve. Comply with MSS SP-60. Install valve with stem pointing up and with valve box.

D. Make connections NPS 2 and smaller with drilling machine according to the following:

1. Install service-saddle assemblies and corporation valves in size, quantity, and arrangement required by utility company standards.
2. Install service-saddle assemblies on water-service pipe to be tapped. Position outlets for corporation valves.
3. Use drilling machine compatible with service-saddle assemblies and corporation valves. Drill hole in main. Remove drilling machine and connect water-service piping.
4. Install corporation valves into service-saddle assemblies.
5. Install manifold for multiple taps in water main.
6. Install curb valve in water-service piping with head pointing up and with service box.

E. Comply with NFPA 24 for fire-service-main piping materials and installation.

1. Install copper tube and fittings according to CDA's "Copper Tube Handbook."
F. Install ductile-iron, water-service piping according to AWWA C600 and AWWA M41.

G. Install PE pipe according to ASTM D 2774 and ASTM F 645.

H. Install PVC, AWWA pipe according to ASTM F 645 and AWWA M23.

I. Extend water-service piping and connect to water-supply source and building-water-piping systems at outside face of building wall in locations and pipe sizes indicated.

J. Sleeves are specified in Section 22 05 17 "Sleeves and Sleeve Seals for Plumbing Piping."

K. Mechanical sleeve seals are specified in Section 22 05 17 "Sleeves and Sleeve Seals for Plumbing Piping."

3.5 JOINT CONSTRUCTION

A. See Section 33 05 00 "Common Work Results for Utilities" for basic piping joint construction.

B. Make pipe joints according to the following:

4. PE Piping Insert-Fitting Joints: Use plastic insert fittings and fasteners according to fitting manufacturer's written instructions.
5. PVC Piping Gasketed Joints: Use joining materials according to AWWA C900. Construct joints with elastomeric seals and lubricant according to ASTM D 2774 or ASTM D 3139 and pipe manufacturer's written instructions.
6. Dissimilar Materials Piping Joints: Use adapters compatible with both piping materials, with OD, and with system working pressure.

3.6 ANCHORAGE INSTALLATION

A. Anchorage, General: Install water-distribution piping with restrained joints. Anchorages and restrained-joint types that may be used include the following:

1. Concrete thrust blocks.
2. Locking mechanical joints.
4. Bolted flanged joints.
5. Heat-fused joints.
6. Pipe clamps and tie rods.

B. Install anchorages for tees, plugs and caps, bends, crosses, valves, and hydrant branches. Include anchorages for the following piping systems:

2. Gasketed-Joint, PVC Water-Service Piping: According to AWWA M23.
C. Apply full coat of asphalt or other acceptable corrosion-resistant material to surfaces of installed ferrous anchorage devices.

3.7 VALVE INSTALLATION

A. AWWA Gate Valves: Comply with AWWA C600 and AWWA M44. Install each underground valve with stem pointing up and with valve box.

B. UL/FMG, Gate Valves: Comply with NFPA 24. Install each underground valve and valves in vaults with stem pointing up and with vertical cast-iron indicator post.

C. MSS Valves: Install as component of connected piping system.

3.8 WATER METER INSTALLATION

A. Install water meters, piping, and specialties according to utility company's written instructions.

B. Water Meters: Install displacement-type water meters, NPS 2 and smaller, in meter boxes with shutoff valves on water meter inlets. Include valves on water meter outlets and valved bypass around meters unless prohibited by authorities having jurisdiction.

C. Water Meters: Install compound-type water meters, NPS 3 and larger, in meter vaults. Include shutoff valves on water meter inlets and outlets and valved bypass around meters. Support meters, valves, and piping on brick or concrete piers.

3.9 BACKFLOW PREVENTER INSTALLATION

A. Install backflow preventers of type, size, and capacity indicated. Include valves and test cocks. Install according to requirements of plumbing and health department and authorities having jurisdiction.

B. Do not install backflow preventers that have relief drain in vault or in other spaces subject to flooding.

C. Do not install bypass piping around backflow preventers.

D. Support NPS 2-1/2 and larger backflow preventers, valves, and piping near floor and on brick or concrete piers.

3.10 CONNECTIONS

A. See Section 33 05 00 "Common Work Results for Utilities" for piping connections to valves and equipment.

B. Connect water-distribution piping to existing water main. Use tapping sleeve and tapping valve.

C. Connect water-distribution piping to interior domestic water piping.
3.11 FIELD QUALITY CONTROL

A. Piping Tests: Conduct piping tests before joints are covered and after concrete thrust blocks have hardened sufficiently. Fill pipeline 24 hours before testing and apply test pressure to stabilize system. Use only potable water.

B. Hydrostatic Tests: Test at not less than one-and-one-half times working pressure for two hours.
   1. Increase pressure in 50-psig increments and inspect each joint between increments. Hold at test pressure for 1 hour; decrease to 0 psig. Slowly increase again to test pressure and hold for 1 more hour. Maximum allowable leakage is 2 quarts per hour per 100 joints. Remake leaking joints with new materials and repeat test until leakage is within allowed limits.

C. Prepare reports of testing activities.

3.12 IDENTIFICATION

A. Permanently attach equipment nameplate or marker indicating plastic water-service piping, on main electrical meter panel. See Section 33 05 00 "Common Work Results for Utilities" for identifying devices.

3.13 CLEANING

A. Clean and disinfect water-distribution piping as follows:
   1. Purge new water-distribution piping systems and parts of existing systems that have been altered, extended, or repaired before use.
   2. Use purging and disinfecting procedure prescribed by authorities having jurisdiction or, if method is not prescribed by authorities having jurisdiction, use procedure described in NFPA 24 for flushing of piping. Flush piping system with clean, potable water until dirty water does not appear at points of outlet.
   3. Use purging and disinfecting procedure prescribed by authorities having jurisdiction or, if method is not prescribed by authorities having jurisdiction, use procedure described in AWWA C651 or do as follows:
      a. Fill system or part of system with water/chlorine solution containing at least 50 ppm of chlorine; isolate and allow to stand for 24 hours.
      b. Drain system or part of system of previous solution and refill with water/chlorine solution containing at least 200 ppm of chlorine; isolate and allow to stand for 3 hours.
      c. After standing time, flush system with clean, potable water until no chlorine remains in water coming from system.
      d. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedure if biological examination shows evidence of contamination.

B. Prepare reports of purging and disinfecting activities.

END OF SECTION 22 11 13
SECTION 22 11 16 - DOMESTIC WATER PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes under-building-slab and aboveground domestic water pipes, tubes, and fittings inside buildings.

B. Related Requirements:

1. Section 22 11 13 "Facility Water Distribution Piping" for water-service piping and water meters outside the building from source to the point where water-service piping enters the building.

1.2 ACTION SUBMITTALS

A. Product Data: For transition fittings and dielectric fittings.

B. LEED Submittals:

1. Product Data for Credit IEQ 4.1: For solvent cements and adhesive primers, documentation including printed statement of VOC content.

2. Laboratory Test Reports for Credit IEQ 4: For solvent cements and adhesive primers, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

1.3 INFORMATIONAL SUBMITTALS

A. System purging and disinfecting activities report.

B. Field quality-control reports.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

A. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

B. Potable-water piping and components shall comply with NSF 14 and NSF 61. Plastic piping components shall be marked with "NSF-pw."

2.2 COPPER TUBE AND FITTINGS

A. Hard Copper Tube: ASTM B 88, Type L water tube, drawn temper.
B. Soft Copper Tube: ASTM B 88, Type K water tube, annealed temper.

C. Cast-Copper, Solder-Joint Fittings: ASME B16.18, pressure fittings.


E. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends.

F. Copper Unions:
   1. MSS SP-123.
   4. Solder-joint or threaded ends.

G. Copper Pressure-Seal-Joint Fittings:
   1. Fittings for NPS 2 and Smaller: Wrought-copper fitting with EPDM-rubber, O-ring seal in each end.
   2. Fittings for NPS 2-1/2 to NPS 4: Cast-bronze or wrought-copper fitting with EPDM-rubber, O-ring seal in each end.

H. Copper Push-on-Joint Fittings:
   1. Cast-copper fitting complying with ASME B16.18 or wrought-copper fitting complying with ASME B 16.22.
   2. Stainless-steel teeth and EPDM-rubber, O-ring seal in each end instead of solder-joint ends.

2.3 DUCTILE-IRON PIPE AND FITTINGS

A. Mechanical-Joint, Ductile-Iron Pipe:
   1. AWWA C151/A21.51, with mechanical-joint bell and plain spigot end unless grooved or flanged ends are indicated.
   2. Glands, Gaskets, and Bolts: AWWA C111/A21.11, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

B. Standard-Pattern, Mechanical-Joint Fittings:
   1. AWWA C110/A21.10, ductile or gray iron.
   2. Glands, Gaskets, and Bolts: AWWA C111/A21.11, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

C. Compact-Pattern, Mechanical-Joint Fittings:
   1. AWWA C153/A21.53, ductile iron.
   2. Glands, Gaskets, and Bolts: AWWA C111/A21.11, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

2.4 GALVANIZED-STEEL PIPE AND FITTINGS

A. Galvanized-Steel Pipe:
1. ASTM A 53/A 53M, Type E, Grade B, Standard Weight.
   2. Include ends matching joining method.


C. Galvanized, Gray-Iron Threaded Fittings: ASME B16.4, Class 125, standard pattern.

D. Malleable-Iron Unions:
   1. ASME B16.39, Class 150.
   2. Hexagonal-stock body.
   4. Threaded ends.

E. Flanges: ASME B16.1, Class 125, cast iron.

2.5 CPVC PIPING

A. CPVC Pipe: ASTM F 441/F 441M, Schedule 40.
   2. CPVC Threaded Fittings: ASTM F 437, Schedule 80.


2.6 PEX TUBE AND FITTINGS

A. PEX Distribution System: ASTM F 877, SDR 9 tubing.

B. Fittings for PEX Tube: ASTM F 1807, metal-insert type with copper or stainless-steel crimp rings and matching PEX tube dimensions.

C. Manifold: Multiple-outlet, plastic or corrosion-resistant-metal assembly complying with ASTM F 877; with plastic or corrosion-resistant-metal valve for each outlet.

2.7 PVC PIPE AND FITTINGS


C. PVC Schedule 80 Threaded Fittings: ASTM D 2464.

2.8 PIPING JOINING MATERIALS

A. Pipe-Flange Gasket Materials:
1. AWWA C110/A21.10, rubber, flat face, 1/8 inch thick or ASME B16.21, nonmetallic and asbestos free unless otherwise indicated.
2. Full-face or ring type unless otherwise indicated.

B. Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.

C. Solder Filler Metals: ASTM B 32, lead-free alloys.

D. Flux: ASTM B 813, water flushable.

E. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.

F. Solvent Cements for Joining CPVC Piping and Tubing: ASTM F 493.
   1. CPVC solvent cement shall have a VOC content of 490 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   2. Adhesive primer shall have a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   3. Solvent cement and adhesive primer shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

G. Solvent Cements for Joining PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.
   1. PVC solvent cement shall have a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   2. Adhesive primer shall have a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   3. Solvent cement and adhesive primer shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

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

2.9 TRANSITION FITTINGS

A. General Requirements:
   1. Same size as pipes to be joined.
   2. Pressure rating at least equal to pipes to be joined.
   3. End connections compatible with pipes to be joined.

B. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.

C. Plastic-to-Metal Transition Fittings:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      b. Harvel Plastics, Inc.
2. Description:
   a. CPVC or PVC one-piece fitting with manufacturer's Schedule 80 equivalent dimensions.
   b. One end with threaded brass insert and one solvent-cement-socket or threaded end.

D. Plastic-to-Metal Transition Unions:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Colonial Engineering, Inc.
   b. NIBCO INC.
   c. Spears Manufacturing Company.

2. Description:
   a. CPVC or PVC four-part union.
   b. Brass or stainless-steel threaded end.
   c. Solvent-cement-joint or threaded plastic end.
   d. Rubber O-ring.
   e. Union nut.

2.10 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.

B. Dielectric Unions:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. A.Y. McDonald Mfg. Co.
   b. Capitol Manufacturing Company.
   c. Central Plastics Company.
   d. Hart Industries International, Inc.
   e. Jomar Valve.
   f. Matco-Norca.
   g. Watts; a Watts Water Technologies company.
   h. Wilkins.
   i. Zurn Industries, LLC.


C. Dielectric Flanges:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
b. Central Plastics Company.
c. Matco-Norca.
d. Watts; a Watts Water Technologies company.
e. Wilkins.
f. Zurn Industries, LLC.

3. Factory-fabricated, bolted, companion-flange assembly.
5. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

D. Dielectric-Flange Insulating Kits:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Advance Products & Systems, Inc.
   b. Calpico, Inc.
   c. Central Plastics Company.
   d. Pipeline Seal and Insulator, Inc.

2. Nonconducting materials for field assembly of companion flanges.
4. Gasket: Neoprene or phenolic.
5. Bolt Sleeves: Phenolic or polyethylene.

E. Dielectric Nipples: NOT PERMITTED

PART 3 - EXECUTION

3.1 EARTHWORK
   A. Comply with requirements in Section 312000 "Earth Moving" for excavating, trenching, and backfilling.

3.2 PIPING INSTALLATION
   A. Drawing plans, schematics, and diagrams indicate general location and arrangement of domestic water piping. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on coordination drawings.

   B. Install copper tubing under building slab according to CDA's "Copper Tube Handbook."

   C. Install ductile-iron piping under building slab with restrained joints according to AWWA C600 and AWWA M41.

   D. Install shutoff valve, hose-end drain valve, strainer, pressure gage, and test tee with valve inside the building at each domestic water-service entrance. Comply with requirements for pressure gages in
Section 22 05 19 "Meters and Gages for Plumbing Piping" and with requirements for drain valves and strainers in Section 22 11 19 "Domestic Water Piping Specialties."

E. Install shutoff valve immediately upstream of each dielectric fitting.

F. Install water-pressure-reducing valves downstream from shutoff valves. Comply with requirements for pressure-reducing valves in Section 22 11 19 "Domestic Water Piping Specialties."

G. Install domestic water piping level without pitch and plumb.

H. Rough-in domestic water piping for water-meter installation according to utility company's requirements.

I. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices in Section 22 05 48 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

J. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.

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

L. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal, and coordinate with other services occupying that space.

M. Install piping to permit valve servicing.

N. Install nipples, unions, special fittings, and valves with pressure ratings the same as or higher than the system pressure rating used in applications below unless otherwise indicated.

O. Install piping free of sags and bends.

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

Q. Install PEX piping with loop at each change of direction of more than 90 degrees.

R. Install unions in copper tubing at final connection to each piece of equipment, machine, and specialty.

S. Install pressure gages on suction and discharge piping for each plumbing pump and packaged booster pump. Comply with requirements for pressure gages in Section 22 05 19 "Meters and Gages for Plumbing Piping."

T. Install thermostats in hot-water circulation piping. Comply with requirements for thermostats in Section 22 11 23 "Domestic Water Pumps."

U. Install thermometers on inlet and outlet piping from each water heater. Comply with requirements for thermometers in Section 22 05 19 "Meters and Gages for Plumbing Piping."

V. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 22 05 17 "Sleeves and Sleeve Seals for Plumbing Piping."

W. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 22 05 17 "Sleeves and Sleeve Seals for Plumbing Piping."
X. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 22 05 18 "Escutcheons for Plumbing Piping."

3.3 JOINT CONSTRUCTION

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

B. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.

C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
   1. Apply appropriate tape or thread compound to external pipe threads.
   2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.

D. Brazed Joints for Copper Tubing: Comply with CDA's "Copper Tube Handbook," "Brazed Joints" chapter.

E. Soldered Joints for Copper Tubing: Apply ASTM B 813, water-flushable flux to end of tube. Join copper tube and fittings according to ASTM B 828 or CDA's "Copper Tube Handbook."

F. Pressure-Sealed Joints for Copper Tubing: Join copper tube and pressure-seal fittings with tools recommended by fitting manufacturer.

G. Flanged Joints: Select appropriate asbestos-free, nonmetallic gasket material in size, type, and thickness suitable for domestic water service. Join flanges with gasket and bolts according to ASME B31.9.

H. Joint Construction for Solvent-Cemented Plastic Piping: Clean and dry joining surfaces. Join pipe and fittings according to the following:
   2. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
   3. PVC Piping: Join according to ASTM D 2855.

I. Joints for PEX Piping: Join according to ASTM F 1807.

J. Joints for Dissimilar-Material Piping: Make joints using adapters compatible with materials of both piping systems.

3.4 TRANSITION FITTING INSTALLATION

A. Install transition couplings at joints of dissimilar piping.

B. Transition Fittings in Underground Domestic Water Piping:
   1. Fittings for NPS 1-1/2 and Smaller: Fitting-type coupling.
   2. Fittings for NPS 2 and Larger: Sleeve-type coupling.
C. Transition Fittings in Aboveground Domestic Water Piping NPS 2 and Smaller: Plastic-to-metal transition fittings or unions.

3.5 DIELECTRIC FITTING INSTALLATION

A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.

B. Dielectric Fittings for NPS 2 and Smaller: Use dielectric couplings no nipples allowed. Provide isolation valves on each side of dielectric unions.

C. Dielectric Fittings for NPS 2-1/2 to NPS 4: Use dielectric flanges.

D. Dielectric Fittings for NPS 5 and Larger: Use dielectric flange kits.

3.6 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements for seismic-restraint devices in Section 22 05 48 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

B. Comply with requirements for pipe hanger, support products, and installation in Section 22 05 29 "Hangers and Supports for Plumbing Piping and Equipment."

1. Vertical Piping: MSS Type 8 or 42, clamps.
2. Individual, Straight, Horizontal Piping Runs:
   a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
   b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
   c. Longer Than 100 Feet if Indicated: MSS Type 49, spring cushion rolls.
3. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
4. Base of Vertical Piping: MSS Type 52, spring hangers.

C. Support vertical piping and tubing at base and at each floor.

D. Rod diameter may be reduced one size for double-rod hangers, to a minimum of 3/8 inch.

E. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 3/4 and Smaller: 60 inches with 3/8-inch rod.
   2. NPS 1 and NPS 1-1/4: 72 inches with 3/8-inch rod.
   3. NPS 1-1/2 and NPS 2: 96 inches with 3/8-inch rod.
   4. NPS 2-1/2: 108 inches with 1/2-inch rod.
   5. NPS 3 to NPS 5: 10 feet with 1/2-inch rod.
   6. NPS 6: 10 feet with 5/8-inch rod.
   7. NPS 8: 10 feet with 3/4-inch rod.

F. Install supports for vertical copper tubing every 10 feet.

G. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:
1. NPS 1-1/4 and Smaller: 84 inches with 3/8-inch rod.
2. NPS 1-1/2: 108 inches with 3/8-inch rod.
3. NPS 2: 10 feet with 3/8-inch rod.
4. NPS 2-1/2: 11 feet with 1/2-inch rod.
5. NPS 3 and NPS 3-1/2: 12 feet with 1/2-inch rod.
6. NPS 4 and NPS 5: 12 feet with 5/8-inch rod.
7. NPS 6: 12 feet with 3/4-inch rod.
8. NPS 8 to NPS 12: 12 feet with 7/8-inch rod.

H. Install supports for vertical steel piping every 15 feet.

I. Install vinyl-coated hangers for CPVC piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1 and Smaller: 36 inches with 3/8-inch rod.
2. NPS 1-1/4 to NPS 2: 48 inches with 3/8-inch rod.
3. NPS 2-1/2 to NPS 3-1/2: 48 inches with 1/2-inch rod.
4. NPS 4 and NPS 5: 48 inches with 5/8-inch rod.
5. NPS 6: 48 inches with 3/4-inch rod.
6. NPS 8: 48 inches with 7/8-inch rod.

J. Install supports for vertical CPVC piping every 60 inches for NPS 1 and smaller, and every 72 inches for NPS 1-1/4 and larger.

K. Install vinyl-coated hangers for PEX piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1 and Smaller: 32 inches with 3/8-inch rod.

L. Install hangers for vertical PEX piping every 48 inches.

M. Install vinyl-coated hangers for PVC piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 2 and Smaller: 48 inches with 3/8-inch rod.
2. NPS 2-1/2 to NPS 3-1/2: 48 inches with 1/2-inch rod.
3. NPS 4 and NPS 5: 48 inches with 5/8-inch rod.
4. NPS 6: 48 inches with 3/4-inch rod.
5. NPS 8: 48 inches with 7/8-inch rod.

N. Install supports for vertical PVC piping every 48 inches.

O. Support piping and tubing not listed in this article according to MSS SP-69 and manufacturer's written instructions.

3.7 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. When installing piping adjacent to equipment and machines, allow space for service and maintenance.

C. Connect domestic water piping to exterior water-service piping. Use transition fitting to join dissimilar piping materials.
D. Connect domestic water piping to water-service piping with shutoff valve; extend and connect to the following:

1. Domestic Water Booster Pumps: Cold-water suction and discharge piping.
2. Water Heaters: Cold-water inlet and hot-water outlet piping in sizes indicated, but not smaller than sizes of water heater connections.
3. Plumbing Fixtures: Cold- and hot-water-supply piping in sizes indicated, but not smaller than that required by plumbing code.
4. Equipment: Cold- and hot-water-supply piping as indicated, but not smaller than equipment connections. Provide shutoff valve and union for each connection. Use flanges instead of unions for NPS 2-1/2 and larger.

3.8 IDENTIFICATION

A. Identify system components. Comply with requirements for identification materials and installation in Section 22 05 53 "Identification for Plumbing Piping and Equipment."

B. Label pressure piping with system operating pressure.

3.9 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Piping Inspections:
   a. Do not enclose, cover, or put piping into operation until it has been inspected and approved by authorities having jurisdiction.
   b. During installation, notify authorities having jurisdiction at least one day before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction:
      1) Roughing-in Inspection: Arrange for inspection of piping before concealing or closing in after roughing in and before setting fixtures.
      2) Final Inspection: Arrange for authorities having jurisdiction to observe tests specified in "Piping Tests" Subparagraph below and to ensure compliance with requirements.
   c. Reinspection: If authorities having jurisdiction find that piping will not pass tests or inspections, make required corrections and arrange for reinspection.
   d. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

2. Piping Tests:
   a. Fill domestic water piping. Check components to determine that they are not air bound and that piping is full of water.
   b. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit a separate report for each test, complete with diagram of portion of piping tested.
   c. Leave new, altered, extended, or replaced domestic water piping uncovered and unconcealed until it has been tested and approved. Expose work that was covered or concealed before it was tested.
   d. Cap and subject piping to static water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow
it to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.

e. Repair leaks and defects with new materials, and retest piping or portion thereof until satisfactory results are obtained.

f. Prepare reports for tests and for corrective action required.

B. Domestic water piping will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.10 ADJUSTING

A. Perform the following adjustments before operation:

1. Close drain valves, hydrants, and hose bibbs.
2. Open shutoff valves to fully open position.
3. Open throttling valves to proper setting.
4. Adjust balancing valves in hot-water-circulation return piping to provide adequate flow.

a. Manually adjust ball-type balancing valves in hot-water-circulation return piping to provide hot-water flow in each branch.

b. Adjust calibrated balancing valves to flows indicated.

5. Remove plugs used during testing of piping and for temporary sealing of piping during installation.
7. Remove filter cartridges from housings and verify that cartridges are as specified for application where used and are clean and ready for use.
8. Check plumbing specialties and verify proper settings, adjustments, and operation.

3.11 CLEANING

A. Clean and disinfect potable domestic water piping as follows:

1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
2. Use purging and disinfecting procedures prescribed by authorities having jurisdiction; if methods are not prescribed, use procedures described in either AWWA C651 or AWWA C652 or follow procedures described below:

a. Flush piping system with clean, potable water until dirty water does not appear at outlets.

b. Fill and isolate system according to either of the following:

1) Fill system or part thereof with water/chlorine solution with at least 50 ppm of chlorine. Isolate with valves and allow to stand for 24 hours.
2) Fill system or part thereof with water/chlorine solution with at least 200 ppm of chlorine. Isolate and allow to stand for three hours.

c. Flush system with clean, potable water until no chlorine is in water coming from system after the standing time.

d. Repeat procedures if biological examination shows contamination.

e. Submit water samples in sterile bottles to authorities having jurisdiction.
B. Prepare and submit reports of purging and disinfecting activities. Include copies of water-sample approvals from authorities having jurisdiction.

C. Clean interior of domestic water piping system. Remove dirt and debris as work progresses.

### 3.12 PIPING SCHEDULE

A. Transition and special fittings with pressure ratings at least equal to piping rating may be used in applications below unless otherwise indicated.

B. Flanges and unions may be used for aboveground piping joints unless otherwise indicated.

C. Fitting Option: Extruded-tee connections and brazed joints may be used on aboveground copper tubing.

D. Under-building-slab, domestic water, building-service piping, NPS 3 and smaller, shall be one of the following:
   1. Soft copper tube, ASTM B 88, Type K; wrought-copper, solder-joint fittings; and brazed joints.

E. Under-building-slab, domestic water, building-service piping, NPS 4 to NPS 8 and larger, shall be one of the following:
   1. Soft copper tube, ASTM B 88, Type K; wrought-copper, solder-joint fittings; and brazed joints.
   2. Plain-end, ductile-iron pipe; grooved-joint, ductile-iron-pipe appurtenances; and grooved joints.

F. Aboveground domestic water piping, NPS 8 and smaller, shall be one of the following:
   1. Hard copper tube, ASTM B 88, Type L; cast- or wrought-copper, solder-joint fittings; and soldered joints.
   2. Hard copper tube, ASTM B 88, Type L; copper pressure-seal-joint fittings; and pressure-sealed joints.

### 3.13 TRAINING

A. Training will be performed for each system installed. Training is to be two separate identical sessions, held on separate weeks. A training Agenda will be developed by the Commissioning Authority. Contractor is responsible to have a competent party perform training, preferably the site foreman in conjunction with manufacturer’s representatives.

END OF SECTION 22 11 16
SECTION 22 11 19 - DOMESTIC WATER PIPING SPECIALTIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Vacuum breakers.
2. Backflow preventers.
5. Temperature-actuated, water mixing valves.
7. Hose bibbs.
8. Wall hydrants.
10. Water-hammer arresters.
11. Trap-seal primer valves.

B. Related Requirements:

1. Section 22 05 19 "Meters and Gages for Plumbing Piping" for thermometers, pressure gages, and flow meters in domestic water piping.
2. Section 22 11 16 "Domestic Water Piping" for water meters.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR PIPING SPECIALTIES

A. Potable-water piping and components shall comply with NSF 61 and NSF 14. Mark "NSF-pw" on plastic piping components.
2.2 PERFORMANCE REQUIREMENTS

A. Minimum Working Pressure for Domestic Water Piping Specialties: 125 psig unless otherwise indicated.

2.3 VACUUM BREAKERS

A. Pipe-Applied, Atmospheric-Type Vacuum Breakers:
   2. Size: NPS 1/4 to NPS 3, as required to match connected piping.
   4. Inlet and Outlet Connections: Threaded.
   5. Finish: Chrome plated.

B. Hose-Connection Vacuum Breakers:
   2. Body: Bronze, nonremovable, with manual drain.
   4. Finish: Chrome or nickel plated.

2.4 BACKFLOW PREVENTERS

A. Intermediate Atmospheric-Vent Backflow Preventers:
   1. Standard: ASSE 1012.
   2. Operation: Continuous-pressure applications.
   5. End Connections: Union, solder joint.

B. Reduced-Pressure-Principle Backflow Preventers:
   2. Operation: Continuous-pressure applications.
   3. Pressure Loss: 12 psig maximum, through middle third of flow range.
   4. Size: See plans.
   5. Design Flow Rate: 150 gpm.
   7. Pressure Loss at Design Flow Rate: 12 psig for sizes NPS 2 and smaller; 12 psig for NPS 2-1/2 and larger.
   8. Body: Bronze for NPS 2 and smaller; cast iron with interior lining that complies with AWWA C550 or that is FDA approved for NPS 2-1/2 and larger.
   9. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
10. Configuration: Designed for horizontal, straight-through flow.
11. Accessories:
    a. Valves NPS 2 and Smaller: Ball type with threaded ends on inlet and outlet.
    b. Valves NPS 2-1/2 and Larger: Outside-screw and yoke-gate type with flanged ends on inlet and outlet.

C. Double-Check, Backflow-Prevention Assemblies Insert drawing designation if any:

2. Operation: Continuous-pressure applications unless otherwise indicated.
3. Pressure Loss: 5 psig maximum, through middle third of flow range.
4. Body: Bronze for NPS 2 and smaller; cast iron with interior lining that complies with AWWA C550 or that is FDA approved for NPS 2-1/2 and larger.
5. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
6. Configuration: Designed for horizontal, straight-through flow.
7. Accessories:
   a. Valves NPS 2 and Smaller: Ball type with threaded ends on inlet and outlet.
   b. Valves NPS 2-1/2 and Larger: Outside-screw and yoke-gate type with flanged ends on inlet and outlet.

2.5 WATER PRESSURE-REDUCING VALVES

A. Water Regulators:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Cash Acme.
   b. Conbraco Industries, Inc.
   c. Honeywell Water Controls.
   d. Watts; a Watts Water Technologies company.
   e. Zurn Industries, LLC.
4. Size: See plans.
5. Design Flow Rate: .
8. Body: Bronze for NPS 2 and smaller; cast iron with interior lining that complies with AWWA C550 or that is FDA approved for NPS 2-1/2 and NPS 3.
10. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and NPS 3.

2.6 BALANCING VALVES

A. Memory-Stop Balancing Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Conbraco Industries, Inc.
   b. Crane; Crane Energy Flow Solutions.
   c. Hammond Valve.
   d. Milwaukee Valve Company.
e. NIBCO INC.
f. Red-White Valve Corporation.

2. Standard: MSS SP-110 for two-piece, copper-alloy ball valves.
3. Pressure Rating: 400-psig minimum CWP.
4. Size: NPS 2 or smaller.
5. Body: Copper alloy.
6. Port: Standard or full port.
7. Ball: Chrome-plated brass.
8. Seats and Seals: Replaceable.
9. End Connections: Solder joint or threaded.

2.7 TEMPERATURE-ACTUATED, WATER MIXING VALVES

A. Water-Temperature Limiting Devices:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   
b. Cash Acme.
c. Conbraco Industries, Inc.
d. Honeywell Water Controls.
e. Legend Valve.
f. Leonard Valve Company.
g. Powers.
h. Symmons Industries, Inc.
i. TACO Incorporated.
j. Watts; a Watts Water Technologies company.
k. Zurn Industries, LLC.

4. Type: Thermostatically controlled, water mixing valve.
5. Material: Bronze body with corrosion-resistant interior components.
6. Connections: Threaded union inlets and outlet.
7. Accessories: Check stops on hot- and cold-water supplies, and adjustable, temperature-control handle.
8. Tempered-Water Setting: 110 deg F.
10. Valve Finish: Rough bronze.

B. Primary, Thermostatic, Water Mixing Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   
b. Lawler Manufacturing Company, Inc.
c. Leonard Valve Company.
d. Powers.
e. Symmons Industries, Inc.
f. Zurn Industries, LLC.
3. Pressure Rating: 125 psig minimum unless otherwise indicated.
4. Type: Exposed-mounted and Cabinet-type, thermostatically controlled, water mixing valve.
5. Material: Bronze body with corrosion-resistant interior components.
6. Connections: Threaded union inlets and outlet.
7. Accessories: Manual temperature control, check stops on hot- and cold-water supplies, and adjustable, temperature-control handle.
8. Tempered-Water Setting: 110 deg F.
9. Tempered-Water Design Flow Rate: 
10. Selected Valve Flow Rate at 45-psig Pressure Drop: 
11. Pressure Drop at Design Flow Rate: See schedule.
13. Piping Finish: Copper.

2.8 STRAINERS FOR DOMESTIC WATER PIPING

A. Y-Pattern Strainers:
1. Pressure Rating: 125 psig minimum unless otherwise indicated.
2. Body: Bronze for NPS 2 and smaller; cast iron with interior lining that complies with AWWA C550 or that is FDA approved, epoxy coated and for NPS 2-1/2 and larger.
3. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
4. Screen: Stainless steel with round perforations unless otherwise indicated.
5. Perforation Size:
   a. Strainers NPS 2 and Smaller: 0.020 inch.
   b. Strainers NPS 2-1/2 to NPS 4: 0.045 inch.
   c. Strainers NPS 5 and Larger: 0.10 inch.

2.9 HOSE BIBBS

A. Hose Bibbs:
4. Supply Connections: NPS 1/2 or NPS 3/4 threaded or solder-joint inlet.
5. Outlet Connection: Garden-hose thread complying with ASME B1.20.7.
8. Finish for Equipment Rooms: Rough bronze, or chrome or nickel plated.
9. Finish for Service Areas: Chrome or nickel plated.
10. Finish for Finished Rooms: Chrome or nickel plated.
11. Operation for Equipment Rooms: Wheel handle or operating key.
14. Include operating key with each operating-key hose bibb.
15. Include integral wall flange with each chrome- or nickel-plated hose bibb.
# 2.10 WALL HYDRANTS

A. Nonfreeze Wall Hydrants:

3. Operation: Loose key.
4. Casing and Operating Rod: Of length required to match wall thickness. Include wall clamp.
5. Inlet: NPS 3/4 or NPS 1.
6. Outlet: Concealed, with integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.
7. Box: Deep, flush mounted with cover.
8. Box and Cover Finish: Polished nickel bronze.
11. Operating Keys(s): One with each wall hydrant.

# 2.11 DRAIN VALVES

A. Ball-Valve-Type, Hose-End Drain Valves:

2. Pressure Rating: 400-psig minimum CWP.
4. Body: Copper alloy.
5. Ball: Chrome-plated brass.
8. Inlet: Threaded or solder joint.

# 2.12 WATER-HAMMER ARRESTERS

A. Water-Hammer Arresters:

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

   a. AMTROL, Inc.
   b. Josam Company.
   c. MIFAB, Inc.
   d. Precision Plumbing Products, Inc.
   e. Sioux Chief Manufacturing Company, Inc.
   g. Tyler Pipe; a subsidiary of McWane Inc.
   h. Watts; a Watts Water Technologies company.
   i. Zurn Industries, LLC.

3. Type: Copper tube with piston.
4. Size: ASSE 1010, Sizes AA and A through F, or PDI-WH 201, Sizes A through F.

### 2.13 TRAP-SEAL PRIMER DEVICE

**A. Supply-Type, Trap-Seal Primer Device:**

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

   a. MIFAB, Inc.
   b. Precision Plumbing Products, Inc.
   c. Sioux Chief Manufacturing Company, Inc.
   e. Watts; a Watts Water Technologies company.
   f. Zurn Industries, LLC.

5. Inlet and Outlet Connections: NPS 1/2 threaded, union, or solder joint.
6. Gravity Drain Outlet Connection: NPS 1/2 threaded or solder joint.
7. Finish: Chrome plated, or rough bronze for units used with pipe or tube that is not chrome finished.

**B. Drainage-Type, Trap-Seal Primer Device:**

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


### PART 3 - EXECUTION

#### 3.1 INSTALLATION

**A.** Install backflow preventers in each water supply to mechanical equipment and systems and to other equipment and water systems that may be sources of contamination. Comply with authorities having jurisdiction.

1. Locate backflow preventers in same room as connected equipment or system.
2. Install drain for backflow preventers with atmospheric-vent drain connection with air-gap fitting, fixed air-gap fitting, or equivalent positive pipe separation of at least two pipe diameters in drain piping and pipe-to-floor drain. Locate air-gap device attached to or under backflow preventer. Simple air breaks are unacceptable for this application.
3. Do not install bypass piping around backflow preventers.

**B.** Install water regulators with inlet and outlet shutoff valves. Install pressure gages on inlet and outlet.
C. Install balancing valves in locations where they can easily be adjusted.

D. Install temperature-actuated, water mixing valves with check stops or shutoff valves on inlets and with shutoff valve on outlet.
   1. Install cabinet-type units recessed in wall as specified.

E. Install Y-pattern strainers for water on supply side of each control valve water pressure-reducing valve solenoid valve and pump.

F. Set nonfreeze, nondraining-type post hydrants in concrete or pavement.

G. Set freeze-resistant yard hydrants with riser pipe in concrete or pavement. Do not encase canister in concrete.

H. Install water-hammer arresters in water piping according to PDI-WH 201.

I. Install supply-type, trap-seal primer valves with outlet piping pitched down toward drain trap a minimum of 1 percent, and connect to floor-drain body, trap, or inlet fitting. Adjust valve for proper flow.

J. Install drainage-type, trap-seal primer valves as lavatory trap with outlet piping pitched down toward drain trap a minimum of 1 percent, and connect to floor-drain body, trap, or inlet fitting.

3.2 CONNECTIONS

A. Comply with requirements for ground equipment in Section 26 05 26 "Grounding and Bonding for Electrical Systems."

B. Fire-retardant-treated-wood blocking is specified in Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables" for electrical connections.

3.3 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:
   1. Test each pressure vacuum breaker double-check, backflow-prevention assembly according to authorities having jurisdiction and the device's reference standard.

B. Domestic water piping specialties will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

3.4 ADJUSTING

A. Set field-adjustable pressure set points of water pressure-reducing valves.

B. Set field-adjustable flow set points of balancing valves.

C. Set field-adjustable temperature set points of temperature-actuated, water mixing valves.
SECTION 22 13 13 - FACILITY SANITARY SEWERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Pipe and fittings.
   2. Nonpressure and pressure couplings.
   3. Expansion joints.
   5. Encasement for piping.

1.2 ACTION SUBMITTALS

A. Product Data: For expansion joints.

B. Shop Drawings: For manholes. Include plans, elevations, sections, details, and frames and covers.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show pipe sizes, locations, and elevations. Show other piping in same trench and clearances from sewer system piping. Indicate interface and spatial relationship between manholes, piping, and proximate structures.

B. Product Certificates: For each type of cast-iron soil pipe and fitting, from manufacturer.

C. Field quality-control reports.

PART 2 - PRODUCTS

2.1 HUB-AND-SPIGOT, CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: ASTM A 74, Service and Extra-Heavy classes.

B. Gaskets: ASTM C 564, rubber.

C. Calking Materials: ASTM B 29, pure lead and oakum or hemp fiber.

2.2 HUBLESS CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: ASTM A 888 or CISPI 301.

B. CISPI-Trademark, Shielded Couplings:
1. **Manufacturers:** Subject to compliance with requirements, provide products by one of the following:
   
   a. ANACO-Husky.
   c. Fernco Inc.
   d. Mission Rubber Company, LLC; a division of MCP Industries.
   e. Stant.
   f. Tyler Pipe; a subsidiary of McWane Inc.

2. **Description:** ASTM C 1277 and CISPI 310, with stainless-steel corrugated shield; stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop.

C. **Heavy-Duty, Shielded Couplings:**

1. **Manufacturers:** Subject to compliance with requirements, provide products by one of the following:
   
   a. ANACO-Husky.
   b. Clamp-All Corp.
   d. Mission Rubber Company, LLC; a division of MCP Industries.
   e. Stant.
   f. Tyler Pipe; a subsidiary of McWane Inc.

2. **Description:** ASTM C 1277 and ASTM C 1540, with stainless-steel shield; stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop.

2.3 **PVC PIPE AND FITTINGS**

A. **PVC Type PSM Sewer Piping:**

1. **Pipe:** ASTM D 3034, PVC Type PSM sewer pipe with bell-and-spigot ends for gasketed joints.
2. **Fittings:** ASTM D 3034, PVC with bell ends.
3. **Gaskets:** ASTM F 477, elastomeric seals.

2.4 **NONPRESSURE-TYPE TRANSITION COUPLINGS**

A. Comply with ASTM C 1173, elastomeric, sleeve-type, reducing or transition coupling, for joining underground nonpressure piping. Include ends of same sizes as piping to be joined and corrosion-resistant-metal tension band and tightening mechanism on each end.

B. **Sleeve Materials:**

1. For Cast-Iron Soil Pipes: ASTM C 564, rubber.
2. For Plastic Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
3. For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.

C. **Unshielded, Flexible Couplings:**
1. Description: Elastomeric sleeve with stainless-steel shear ring and corrosion-resistant-metal tension band and tightening mechanism on each end.

D. Ring-Type, Flexible Couplings: Elastomeric compression seal with dimensions to fit inside bell of larger pipe and for spigot of smaller pipe to fit inside ring.

2.5 EXPANSION JOINTS

A. Ductile-Iron, Flexible Expansion Joints:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. EBAA Iron, Inc.
   b. Romac Industries, Inc.
   c. Star Pipe Products.

2. Description: Compound fitting with combination of flanged and mechanical-joint ends complying with AWWA C110 or AWWA C153. Include two gasketed ball-joint sections and one or more gasketed sleeve sections, rated for 250-psig minimum working pressure and for offset and expansion indicated.

2.6 CLEANOUTS

A. Cast-Iron Cleanouts: ASME A112.36.2M, round, gray-iron housing with clamping device and round, secured, scoriated, gray-iron cover. Include gray-iron ferrule with inside calk or spigot connection and countersunk, tapered-thread, brass closure plug.

1. Top-Loading Classification(s): Heavy Duty.
2. Sewer Pipe Fitting and Riser to Cleanout: ASTM A 74, Service class, cast-iron soil pipe and fittings.

2.7 ENCASEMENT FOR PIPING

A. Standard: ASTM A 674 or AWWA C105.

B. Material: Linear low-density polyethylene film of 0.008-inch or high-density, cross-laminated polyethylene film of 0.004-inch minimum thickness.

C. Form: Sheet or tube.

D. Color: Black or natural.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Excavating, trenching, and backfilling are specified in Section 312000 "Earth Moving."
3.2 PIPING INSTALLATION

A. General Locations and Arrangements: Drawing plans and details indicate general location and arrangement of underground sanitary sewer piping. Location and arrangement of piping layout take into account design considerations. Install piping as indicated, to extent practical. Where specific installation is not indicated, follow piping manufacturer's written instructions.

B. Install piping beginning at low point, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings according to manufacturer's written instructions for using lubricants, cements, and other installation requirements.

C. Install proper size increasers, reducers, and couplings where different sizes or materials of pipes and fittings are connected. Reducing size of piping in direction of flow is prohibited.

D. When installing pipe under streets or other obstructions that cannot be disturbed, use pipe-jacking process of microtunneling.

E. Install gravity-flow, nonpressure, drainage piping according to the following:
   1. Install piping pitched down in direction of flow, at minimum slope of 1 percent unless otherwise indicated.
   2. Install piping NPS 6 and larger with restrained joints at tee fittings and at changes in direction. Use corrosion-resistant rods, pipe or fitting manufacturer's proprietary restraint system, or cast-in-place-concrete supports or anchors.
   3. Install piping with 60-inch minimum cover.
   5. Install hubless cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook."
   6. Install PVC Type PSM sewer piping according to ASTM D 2321 and ASTM F 1668.

F. Install corrosion-protection piping encasement over the following underground metal piping according to ASTM A 674 or AWWA C105:
   2. Hubless cast-iron soil pipe and fittings.
   3. Expansion joints.

G. Clear interior of piping and manholes of dirt and superfluous material as work progresses. Maintain swab or drag in piping, and pull past each joint as it is completed. Place plug in end of incomplete piping at end of day and when work stops.

3.3 PIPE JOINT CONSTRUCTION

A. Join gravity-flow, nonpressure, drainage piping according to the following:
4. Join PVC Type PSM sewer piping according to ASTM D 2321 and ASTM D 3034 for elastomeric-seal joints or ASTM D 3034 for elastomeric-gasket joints.
5. Join dissimilar pipe materials with nonpressure-type, flexible couplings.

B. Pipe couplings with pressure ratings at least equal to piping rating may be used in applications below unless otherwise indicated.

1. Use nonpressure flexible couplings where required to join gravity-flow, nonpressure sewer piping unless otherwise indicated.
   a. Unshielded flexible couplings for pipes of same or slightly different OD.
   b. Unshielded, increaser/reducer-pattern, flexible couplings for pipes with different OD.
   c. Ring-type flexible couplings for piping of different sizes where annular space between smaller piping’s OD and larger piping’s ID permits installation.

3.4 CLEANOUT INSTALLATION

A. Install cleanouts and riser extensions from sewer pipes to cleanouts at grade. Use cast-iron soil pipe fittings in sewer pipes at branches for cleanouts, and use cast-iron soil pipe for riser extensions to cleanouts. Install piping so cleanouts open in direction of flow in sewer pipe.

   1. Use Light-Duty, top-loading classification cleanouts in earth or unpaved foot-traffic areas.
   2. Use Medium-Duty, top-loading classification cleanouts in paved foot-traffic areas.
   3. Use Heavy-Duty, top-loading classification cleanouts in vehicle-traffic service areas.

B. Set cleanout frames and covers in earth in cast-in-place-concrete block, 18 by 18 by 12 inches deep. Set with tops 1 inch above surrounding grade.

C. Set cleanout frames and covers in concrete pavement and roads with tops flush with pavement surface.

3.5 CONNECTIONS

A. Connect nonpressure, gravity-flow drainage piping to building’s sanitary building drains specified in Section 221316 “Sanitary Waste and Vent Piping.”

B. Make connections to existing piping.

   1. Use commercially manufactured wye fittings for piping branch connections. Remove section of existing pipe, install wye fitting into existing piping, and encase entire wye fitting plus 6-inch overlap with not less than 6 inches of concrete with 28-day compressive strength of 3000 psi.
   2. Make branch connections from side into existing piping, NPS 4 to NPS 20. Remove section of existing pipe, install wye fitting into existing piping, and encase entire wye with not less than 6 inches of concrete with 28-day compressive strength of 3000 psi.
   3. Make branch connections from side into existing piping, NPS 21 or larger, or to underground manholes by cutting opening into existing unit large enough to allow 3 inches of concrete to be packed around entering connection. Cut end of connection pipe passing through pipe or structure wall to conform to shape of and be flush with inside wall unless otherwise indicated. On outside of pipe or manhole wall, encase entering connection in 6 inches of concrete for minimum length of 12 inches to provide additional support of collar from connection to undisturbed ground.
a. Use concrete that will attain a minimum 28-day compressive strength of 3000 psi unless otherwise indicated.
b. Use epoxy-bonding compound as interface between new and existing concrete and piping materials.

4. Protect existing piping and manholes to prevent concrete or debris from entering while making tap connections. Remove debris or other extraneous material that may accumulate.

C. Connect to grease oil and sand interceptors specified in Section 221323 "Sanitary Waste Interceptors."

3.6 IDENTIFICATION

A. Materials and their installation are specified in Section 312000 "Earth Moving." Arrange for installation of green warning tapes directly over piping and at outside edges of underground manholes.

1. Use detectable warning tape over ferrous piping.
2. Use detectable warning tape over nonferrous piping and over edges of underground manholes.

3.7 FIELD QUALITY CONTROL

A. Inspect interior of piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24 inches of backfill is in place, and again at completion of Project.

1. Submit separate report for each system inspection.
2. Defects requiring correction include the following:
   a. Alignment: Less than full diameter of inside of pipe is visible between structures.
   b. Deflection: Flexible piping with deflection that prevents passage of ball or cylinder of size not less than 92.5 percent of piping diameter.
   c. Damage: Crushed, broken, cracked, or otherwise damaged piping.
   d. Infiltration: Water leakage into piping.
   e. Exfiltration: Water leakage from or around piping.

3. Replace defective piping using new materials, and repeat inspections until defects are within allowances specified.
4. Reinspect and repeat procedure until results are satisfactory.

B. Test new piping systems, and parts of existing systems that have been altered, extended, or repaired, for leaks and defects.

1. Do not enclose, cover, or put into service before inspection and approval.
2. Test completed piping systems according to requirements of authorities having jurisdiction.
3. Schedule tests and inspections by authorities having jurisdiction with at least 24 hours' advance notice.
4. Submit separate report for each test.
5. Hydrostatic Tests: Test sanitary sewerage according to requirements of authorities having jurisdiction and the following:
   a. Fill sewer piping with water. Test with pressure of at least 10-foot head of water, and maintain such pressure without leakage for at least 15 minutes.
   b. Close openings in system and fill with water.
   c. Purge air and refill with water.
d. Disconnect water supply.
e. Test and inspect joints for leaks.

6. Air Tests: Test sanitary sewerage according to requirements of authorities having jurisdiction, UNI-B-6, and the following:
   a. Option: Test plastic gravity sewer piping according to ASTM F 1417.
   b. Option: Test concrete gravity sewer piping according to ASTM C 924.

7. Manholes: Perform hydraulic test according to ASTM C 969.

C. Leaks and loss in test pressure constitute defects that must be repaired.

D. Replace leaking piping using new materials, and repeat testing until leakage is within allowances specified.

3.8 CLEANING

A. Clean dirt and superfluous material from interior of piping. Flush with potable water.

END OF SECTION 22 13 13
SECTION 22 13 16 - SANITARY WASTE AND VENT PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Pipe, tube, and fittings.
2. Specialty pipe fittings.

B. Related Section:

1. Section 221313 "Facility Sanitary Sewers" for sanitary sewerage piping and structures outside the building.

1.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Soil, waste, and vent piping and support and installation shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1.3 ACTION SUBMITTALS

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

B. LEED Submittals:

1. Product Data for Credit IEQ 4.1: For solvent cements and adhesive primers, documentation including printed statement of VOC content.
2. Laboratory Test Reports for Credit IEQ 4: For solvent cements and adhesive primers, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

1.4 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For waste and vent piping, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Detailed description of piping anchorage devices on which the certification is based and their installation requirements.

B. Field quality-control reports.
1.5 QUALITY ASSURANCE

A. Piping materials shall bear label, stamp, or other markings of specified testing agency.


PART 2 - PRODUCTS

2.1 PIPING MATERIALS

A. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

2.2 HUBLESS, CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: ASTM A 888 or CISPI 301.

B. CISPI, Hubless-Piping Couplings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. ANACO-Husky.
   c. Fernco Inc.
   d. Matco-Norca.
   e. MIFAB, Inc.
   f. Mission Rubber Company, LLC; a division of MCP Industries.
   g. Stant.
   h. Tyler Pipe; a subsidiary of McWane Inc.


3. Description: Stainless-steel corrugated shield with stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop.

C. Heavy-Duty, Hubless-Piping Couplings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. ANACO-Husky.
   b. Clamp-All Corp.
   d. MIFAB, Inc.
   e. Mission Rubber Company, LLC; a division of MCP Industries.
   f. Stant.
   g. Tyler Pipe; a subsidiary of McWane Inc.

3. Description: Stainless-steel shield with stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop.

2.3 PVC PIPE AND FITTINGS

A. Solid-Wall PVC Pipe: ASTM D 2665, drain, waste, and vent.

B. PVC Socket Fittings: ASTM D 2665, made to ASTM D 3311, drain, waste, and vent patterns and to fit Schedule 40 pipe.

C. Adhesive Primer: ASTM F 656.
   1. Adhesive primer shall have a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   2. Adhesive primer shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

D. Solvent Cement: ASTM D 2564.
   1. PVC solvent cement shall have a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   2. Solvent cement shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.4 SPECIALTY PIPE FITTINGS

A. Transition Couplings:
   1. General Requirements: Fitting or device for joining piping with small differences in OD's or of different materials. Include end connections same size as and compatible with pipes to be joined.
   2. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.
   3. Unshielded, Nonpressure Transition Couplings:
      a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
         2) Fernco Inc.
         3) Froet Industries LLC.
         4) Mission Rubber Company, LLC; a division of MCP Industries.
         5) Plastic Oddities.
      c. Description: Elastomeric, sleeve-type, reducing or transition pattern. Include shear ring and corrosion-resistant-metal tension band and tightening mechanism on each end.
      d. Sleeve Materials:
         2) For Plastic Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
3) For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.

4. Shielded, Nonpressure Transition Couplings:
   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      2) Mission Rubber Company, LLC; a division of MCP Industries.
   c. Description: Elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.

PART 3 - EXECUTION

3.1 EARTH MOVING
   A. Comply with requirements for excavating, trenching, and backfilling specified in Section 312000 "Earth Moving."

3.2 PIPING INSTALLATION
   A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on coordination drawings.
   B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
   C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
   D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
   E. Install piping at indicated slopes.
   F. Install piping free of sags and bends.
   G. Install fittings for changes in direction and branch connections.
   H. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."
   I. Make changes in direction for soil and waste drainage and vent piping using appropriate branches, bends, and long-sweep bends. Sanitary tees and short-sweep 1/4 bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical. Use long-turn, double Y-branch and 1/8-bend fittings if two fixtures are installed back to back or side by side with common drain pipe. Straight tees, elbows, and crosses may be used on vent lines. Do not change direction of flow more than 90 degrees.
Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.

J. Lay buried building drainage piping beginning at low point of each system. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements. Maintain swab in piping and pull past each joint as completed.

K. Install soil and waste drainage and vent piping at the following minimum slopes unless otherwise indicated:

1. Building Sanitary Drain: 2 percent downward in direction of flow for piping NPS 3 and smaller; 1 percent downward in direction of flow for piping NPS 4 and larger.
2. Vent Piping: 1 percent downward in direction of flow or toward vent stack.

L. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."

M. Install aboveground PVC piping according to ASTM D 2665.

N. Install underground PVC piping according to ASTM D 2321.

O. Plumbing Specialties:

1. Install backwater valves in sanitary waste gravity-flow piping. Comply with requirements for backwater valves specified in Section 221319 "Sanitary Waste Piping Specialties."
2. Install cleanouts at grade and extend to where building sanitary drains connect to building sanitary sewers in sanitary drainage gravity-flow piping. Comply with requirements for cleanouts specified in Section 221319 "Sanitary Waste Piping Specialties."

P. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

Q. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

R. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

S. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."

3.3 JOINT CONSTRUCTION

A. Join hubless, cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-piping coupling joints.

B. Flanged Joints: Align bolt holes. Select appropriate gasket material, size, type, and thickness. Install gasket concentrically positioned. Use suitable lubricants on bolt threads. Torque bolts in cross pattern.
C. Plastic, Nonpressure-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. PVC Piping: Join according to ASTM D 2855 and ASTM D 2665 Appendixes.

3.4 SPECIALTY PIPE FITTING INSTALLATION

A. Transition Couplings:

1. Install transition couplings at joints of piping with small differences in OD's.
2. In Drainage Piping: Shielded, nonpressure transition couplings.

3.5 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements for seismic-restraint devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

B. Comply with requirements for pipe hanger and support devices and installation specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."

1. Install carbon-steel pipe hangers for horizontal piping in noncorrosive environments.
2. Install stainless-steel pipe hangers for horizontal piping in corrosive environments.
3. Install carbon-steel pipe support clamps for vertical piping in noncorrosive environments.
4. Install stainless-steel pipe support clamps for vertical piping in corrosive environments.
5. Vertical Piping: MSS Type 8 or Type 42, clamps.
6. Install individual, straight, horizontal piping runs:
   a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
   b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
   c. Longer Than 100 Feet if Indicated: MSS Type 49, spring cushion rolls.
7. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
8. Base of Vertical Piping: MSS Type 52, spring hangers.

C. Support horizontal piping and tubing within 12 inches of each fitting and coupling.

D. Support vertical piping and tubing at base and at each floor.

E. Rod diameter may be reduced one size for double-rod hangers, with 3/8-inch minimum rods.

F. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/2 and NPS 2: 60 inches with 3/8-inch rod.
2. NPS 3: 60 inches with 1/2-inch rod.
3. NPS 4 and NPS 5: 60 inches with 5/8-inch rod.
4. NPS 6 and NPS 8: 60 inches with 3/4-inch rod.
5. Spacing for 10-foot lengths may be increased to 10 feet. Spacing for fittings is limited to 60 inches.
G. Install supports for vertical cast-iron soil piping every 15 feet.

H. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 1-1/4: 72 inches with 3/8-inch rod.
   2. NPS 1-1/2 and NPS 2: 96 inches with 3/8-inch rod.
   3. NPS 2-1/2: 108 inches with 1/2-inch rod.
   4. NPS 3 and NPS 5: 10 feet with 1/2-inch rod.
   5. NPS 6: 10 feet with 5/8-inch rod.
   6. NPS 8: 10 feet with 3/4-inch rod.

I. Install supports for vertical copper tubing every 10 feet.

J. Install hangers for PVC piping with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 1-1/2 and NPS 2: 48 inches with 3/8-inch rod.
   2. NPS 3: 48 inches with 1/2-inch rod.
   3. NPS 4 and NPS 5: 48 inches with 5/8-inch rod.
   4. NPS 6 and NPS 8: 48 inches with 3/4-inch rod.

K. Install supports for vertical PVC piping every 48 inches.

L. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.

3.6 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect soil and waste piping to exterior sanitary sewerage piping. Use transition fitting to join dissimilar piping materials.

C. Connect drainage and vent piping to the following:
   1. Plumbing Fixtures: Connect drainage piping in sizes indicated, but not smaller than required by plumbing code.
   2. Plumbing Fixtures and Equipment: Connect atmospheric vent piping in sizes indicated, but not smaller than required by authorities having jurisdiction.
   3. Plumbing Specialties: Connect drainage and vent piping in sizes indicated, but not smaller than required by plumbing code.
   4. Install test tees (wall cleanouts) in conductors near floor and floor cleanouts with cover flush with floor.
   5. Install horizontal backwater valves in pit with pit cover flush with floor.
   6. Comply with requirements for backwater valves cleanouts and drains specified in Section 221319 “Sanitary Waste Piping Specialties.”
   7. Equipment: Connect drainage piping as indicated. Provide shutoff valve if indicated and union for each connection. Use flanges instead of unions for connections NPS 2-1/2 and larger.

D. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.

E. Make connections according to the following unless otherwise indicated:
1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.
2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.

3.7 IDENTIFICATION

A. Identify exposed sanitary waste and vent piping. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.8 FIELD QUALITY CONTROL

A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.

1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.

C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

D. Test sanitary drainage and vent piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:

1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
2. Leave uncovered and unconcealed new, altered, extended, or replaced drainage and vent piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
3. Roughing-in Plumbing Test Procedure: Test drainage and vent piping except outside leaders on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water. From 15 minutes before inspection starts to completion of inspection, water level must not drop. Inspect joints for leaks.
4. Finished Plumbing Test Procedure: After plumbing fixtures have been set and traps filled with water, test connections and prove they are gastight and watertight. Plug vent-stack openings on roof and building drains where they leave building. Introduce air into piping system equal to pressure of 1-inch wg. Use U-tube or manometer inserted in trap of water closet to measure this pressure. Air pressure must remain constant without introducing additional air throughout period of inspection. Inspect plumbing fixture connections for gas and water leaks.
5. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
6. Prepare reports for tests and required corrective action.

3.9 CLEANING AND PROTECTION

A. Clean interior of piping. Remove dirt and debris as work progresses.
B. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.

C. Place plugs in ends of uncompleted piping at end of day and when work stops.

D. Exposed PVC Piping: Protect plumbing vents exposed to sunlight with two coats of water-based latex paint.

3.10 PIPING SCHEDULE

A. Flanges and unions may be used on aboveground pressure piping unless otherwise indicated.

B. Aboveground, soil and waste piping NPS 8 and smaller shall be any of the following (if piping is located in a ceiling plenum, utilize cast iron piping only):
   1. Hubless, cast-iron soil pipe and fittings; CISPI hubless-piping couplings; and coupled joints.
   2. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints.

C. Aboveground, vent piping NPS 6 and smaller shall be any of the following (If piping is located in a ceiling plenum, utilize cast iron piping only):
   1. Hubless, cast-iron soil pipe and fittings; CISPI hubless-piping couplings; and coupled joints.
   2. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints.

D. Underground, soil, waste, and vent piping NPS 8 and smaller shall be any of the following:
   1. Hubless, cast-iron soil pipe and fittings; CISPI hubless-piping couplings; and coupled joints.
   2. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints.

END OF SECTION 22 13 16
SECTION 22 13 19 - SANITARY WASTE PIPING SPECIALTIES

PART 1 - GENERAL

1.1 SUMMARY
A. Section Includes:
   1. Cleanouts.
   2. Floor drains.
   3. Roof flashing assemblies.
   5. Flashing materials.

1.2 ACTION SUBMITTALS
A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and accessories for grease interceptors.

1.3 QUALITY ASSURANCE
A. Drainage piping specialties shall bear label, stamp, or other markings of specified testing agency.

PART 2 - PRODUCTS

2.1 CLEANOUTS
A. Exposed Cast-Iron Cleanouts:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      b. MIFAB, Inc.
      d. Tyler Pipe; a subsidiary of McWane Inc.
      e. Watts; a Watts Water Technologies company.
      f. Zurn Industries, LLC.
   2. Standard: ASME A112.36.2M for cast iron for cleanout test tee.
   3. Size: Same as connected drainage piping
   4. Body Material: Hubless, cast-iron soil pipe test tee as required to match connected piping.
   5. Closure: Countersunk or raised-head, brass plug.
   6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.

B. Cast-Iron Floor Cleanouts (F.C.O.):
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   b. Oatey.
   c. Sioux Chief Manufacturing Company, Inc.
   e. Sioux Chief
   f. Watts; a Watts Water Technologies company.
   g. Zurn Industries, LLC.

2. Standard: ASME A112.36.2M for adjustable housing cleanout.
3. Size: Same as connected branch.
4. Type: Adjustable housing.
5. Body or Ferrule: Cast iron.
7. Outlet Connection: Threaded.
8. Closure: Brass plug with tapered threads.
9. Adjustable Housing Material: Cast iron with threads.
11. Frame and Cover Shape: Round.
12. Top Loading Classification: Heavy Duty.
13. Riser: ASTM A 74, Service class, cast-iron drainage pipe fitting and riser to cleanout.
14. Floor drain shall allow adjustment of 1" before concrete pour and 1" after the concrete pour.

C. Cast-Iron Wall Cleanouts (W.C.O.):

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   b. MIFAB, Inc.
   d. Tyler Pipe; a subsidiary of McWane Inc.
   e. Watts; a Watts Water Technologies company.
   f. Zurn Industries, LLC.

2. Standard: ASME A112.36.2M. Include wall access.
3. Size: Same as connected drainage piping.
4. Body: Hubless, cast-iron soil pipe test tee as required to match connected piping.
5. Closure: Raised-head, brass plug.
6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.

2.2 FLOOR DRAINS

A. Cast-Iron Floor Drains:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
b. Josam Company.
c. MIFAB, Inc.
d. Prier Products, Inc.
f. Tyler Pipe; a subsidiary of McWane Inc.
g. Watts; a Watts Water Technologies company.
h. Zurn Industries, LLC.

2. Standard: ASME A112.6.3.
5. Seepage Flange: Required.
7. Top or Strainer Material: Nickel bronze.
8. Top of Body and Strainer Finish: Nickel bronze.
10. Top Loading Classification: Heavy Duty.
11. Trap Material: Cast iron.

2.3 ROOF FLASHING ASSEMBLIES

A. Roof Flashing Assemblies:

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

   b. Thaler Metal Industries Ltd.
   c. Zurn Industries, LLC.

2. Description: Manufactured assembly made of 6.0-lb/sq. ft., 0.0938-inch- thick, lead flashing collar and skirt extending at least 8 inches from pipe, with galvanized-steel boot reinforcement and counterflashing fitting.

   b. Low-Silhouette Vent Cap: With vandal-proof vent cap.
   c. Extended Vent Cap: With field-installed, vandal-proof vent cap.

2.4 MISCELLANEOUS SANITARY DRAINAGE PIPING SPECIALTIES

A. Open Drains:

1. Description: Shop or field fabricate from ASTM A 74, Service class, hub-and-spigot, cast-iron, soil-pipe fittings. Include P-trap, hub-and-spigot riser section; and where required, increaser fitting joined with ASTM C 564, rubber gaskets.

2. Size: Same as connected waste piping with increaser fitting of size indicated.
1. Description: Cast-iron or bronze casting, with inlet and outlet matching connected piping and cleanout trap-seal primer valve connection.
2. Size: Same as connected waste piping.
   a. NPS 2: 4-inch - minimum water seal.
   b. NPS 2-1/2 and Larger: 5-inch - minimum water seal.

C. Floor-Drain, Trap-Seal Primer Fittings:
1. Description: Cast iron, with threaded inlet and threaded or spigot outlet, and trap-seal primer valve connection.
2. Size: Same as floor drain outlet with NPS 1/2 side inlet.

D. Air-Gap Fittings:
1. Standard: ASME A112.1.2, for fitting designed to ensure fixed, positive air gap between installed inlet and outlet piping.
2. Body: Bronze or cast iron.
3. Inlet: Opening in top of body.
4. Outlet: Larger than inlet.
5. Size: Same as connected waste piping and with inlet large enough for associated indirect waste piping.

E. Sleeve Flashing Device:
1. Description: Manufactured, cast-iron fitting, with clamping device, that forms sleeve for pipe floor penetrations of floor membrane. Include galvanized-steel pipe extension in top of fitting that will extend 2 inches above finished floor and galvanized-steel pipe extension in bottom of fitting that will extend through floor slab.
2. Size: As required for close fit to riser or stack piping.

F. Stack Flashing Fittings:
1. Description: Counterflashing-type, cast-iron fitting, with bottom recess for terminating roof membrane, and with threaded or hub top for extending vent pipe.
2. Size: Same as connected stack vent or vent stack.

G. Vent Caps:
1. Description: Cast-iron body with threaded or hub inlet and vandal-proof design. Include vented hood and setscrews to secure to vent pipe.
2. Size: Same as connected stack vent or vent stack.

2.5 FLASHING MATERIALS
A. Lead Sheet: ASTM B 749, Type L51121, copper bearing, with the following minimum weights and thicknesses, unless otherwise indicated:
   1. General Use: 4.0-lb/sq. ft., 0.0625-inch thickness.
   2. Vent Pipe Flashing: 3.0-lb/sq. ft., 0.0469-inch thickness.

B. Fasteners: Metal compatible with material and substrate being fastened.
C. Metal Accessories: Sheet metal strips, clamps, anchoring devices, and similar accessory units required for installation; matching or compatible with material being installed.

D. Solder: ASTM B 32, lead-free alloy.

E. Bituminous Coating: SSPC-Paint 12, solvent-type, bituminous mastic.

2.6 GREASE INTERCEPTORS

A. Grease Interceptors:

1. Cast-Iron or Steel Grease Interceptors:
   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1) Applied Chemical Technology, Incorporated.
      2) Josam Company.
      3) MIFAB, Inc.
      4) Rockford Sanitary Systems, Inc.
      6) Tyler Pipe; a subsidiary of McWane Inc.
      7) Watts; a Watts Water Technologies company.
      8) Zurn Industries, LLC.


3. Plumbing and Drainage Institute Seal: Required.

4. Body Material: Cast iron or steel.

5. Interior Lining: Corrosion-resistant enamel.


7. Body Dimensions:


9. Flow Rate: 15 GPM

10. Grease Retention Capacity:

11. Inlet and Outlet Size: 2"


13. Cleanout: Integral or field installed on outlet.


15. Flow-Control Fitting: Required.


PART 3 - EXECUTION

3.1 INSTALLATION

A. Install backwater valves in building drain piping. For interior installation, provide cleanout deck plate flush with floor and centered over backwater valve cover, and of adequate size to remove valve cover for servicing.
B. Install cleanouts in aboveground piping and building drain piping according to the following, unless otherwise indicated:

1. Size same as drainage piping up to NPS 4. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
2. Locate at each change in direction of piping greater than 45 degrees.
3. Locate at minimum intervals of 50 feet for piping NPS 4 and smaller and 100 feet for larger piping.
4. Locate at base of each vertical soil and waste stack.

C. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.

D. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.

E. Install floor drains at low points of surface areas to be drained. Set grates of drains flush with finished floor, unless otherwise indicated.

1. Position floor drains for easy access and maintenance.
2. Set floor drains below elevation of surrounding finished floor to allow floor drainage. Set with grates depressed according to the following drainage area radii:
   a. Radius, 30 Inches or Less: Equivalent to 1 percent slope, but not less than 1/4-inch total depression.
   b. Radius, 30 to 60 Inches: Equivalent to 1 percent slope.
   c. Radius, 60 Inches or Larger: Equivalent to 1 percent slope, but not greater than 1-inch total depression.
3. Install floor-drain flashing collar or flange so no leakage occurs between drain and adjoining flooring. Maintain integrity of waterproof membranes where penetrated.
4. Install individual traps for floor drains connected to sanitary building drain, unless otherwise indicated.

F. Install roof flashing assemblies on sanitary stack vents and vent stacks that extend through roof.

G. Install flashing fittings on sanitary stack vents and vent stacks that extend through roof.

H. Assemble open drain fittings and install with top of hub 1 inch above floor.

I. Install deep-seal traps on floor drains and other waste outlets, if indicated.

J. Install floor-drain, trap-seal primer fittings on inlet to floor drains that require trap-seal primer connection.

1. Exception: Fitting may be omitted if trap has trap-seal primer connection.
2. Size: Same as floor drain inlet.

K. Install air-gap fittings on draining-type backflow preventers and on indirect-waste piping discharge into sanitary drainage system.

L. Install sleeve flashing device with each riser and stack passing through floors with waterproof membrane.

M. Install vent caps on each vent pipe passing through roof.
N. Install grease interceptors, including trapping, venting, and flow-control fitting, according to authorities having jurisdiction and with clear space for servicing.

1. Above-Floor Installation: Set unit with bottom resting on floor, unless otherwise indicated.

O. Install traps on plumbing specialty drain outlets. Omit traps on indirect wastes unless trap is indicated.

3.2 CONNECTIONS

A. Comply with requirements in Section 221316 "Sanitary Waste and Vent Piping" for piping installation requirements. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to equipment to allow service and maintenance.

C. Grease Interceptors: Connect inlet and outlet to unit, and connect flow-control fitting and vent to unit inlet piping. Install valve on outlet of automatic drawoff-type unit.

3.3 FLASHING INSTALLATION

A. Fabricate flashing from single piece unless large pans, sumps, or other drainage shapes are required. Join flashing according to the following if required:

1. Lead Sheets: Burn joints of lead sheets 6.0-lb/sq. ft., 0.0938-inch thickness or thicker. Solder joints of lead sheets 4.0-lb/sq. ft., 0.0625-inch thickness or thinner.

B. Install sheet flashing on pipes, sleeves, and specialties passing through or embedded in floors and roofs with waterproof membrane.

1. Pipe Flashing: Sleeve type, matching pipe size, with minimum length of 10 inches, and skirt or flange extending at least 8 inches around pipe.
2. Sleeve Flashing: Flat sheet, with skirt or flange extending at least 8 inches around sleeve.
3. Embedded Specialty Flashing: Flat sheet, with skirt or flange extending at least 8 inches around specialty.

C. Set flashing on floors and roofs in solid coating of bituminous cement.

D. Secure flashing into sleeve and specialty clamping ring or device.

E. Install flashing for piping passing through roofs with counterflashing or commercially made flashing fittings, according to Section 076200 "Sheet Metal Flashing and Trim."

F. Extend flashing up vent pipe passing through roofs and turn down into pipe, or secure flashing into cast-iron sleeve having calking recess.

3.4 LABELING AND IDENTIFYING

A. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplate or sign on or near each grease interceptor.

B. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit.
Nameplates and signs are specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.5 PROTECTION

A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.

B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION 22 13 19
SECTION 22 13 29 - SANITARY SEWERAGE PUMPS

PART 1 - GENERAL

1.1 SUMMARY

   A. Section Includes:
      1. Submersible sewage pumps.
      2. Wet-pit-volute sewage pumps.

1.2 ACTION SUBMITTALS

   A. Product Data: For each type of product indicated.
   B. Wiring Diagrams: For power, signal, and control wiring.

1.3 CLOSEOUT SUBMITTALS

   A. Operation and maintenance data.

1.4 QUALITY ASSURANCE

   A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
   B. UL Compliance: Comply with UL 778 for motor-operated water pumps.

PART 2 - PRODUCTS

2.1 SUBMERSIBLE SEWAGE PUMPS

   A. Duplex Submersible, Fixed-Position, Single-Seal Sewage Pumps:
      1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
         a. Bell & Gossett; a Xylem brand.
         b. Liberty Pumps.
         c. Little Giant Pump Co.
         d. PACO Pumps; Grundfos Pumps Corporation, USA.
         e. Peerless Pump Company.
         f. Weil Pump Company, Inc.
         g. Weinman; a Crane Pumps & Systems brand.
         h. Zoeller Company.
2. Description: Factory-assembled and tested duplex sewage-pump unit.
3. Pump Type: Submersible, end-suction, single-stage, close-coupled, overhung-impeller, centrifugal sewage pump as defined in HI 1.1-1.2 and HI 1.3.
4. Pump Casing: Cast iron, with open inlet, legs that elevate pump to permit flow into impeller, and vertical discharge for piping connection.
5. Impeller: Statically and dynamically balanced, ASTM A 48/A 48M, Class No. 25 A cast iron, nonclog, open, or semiopen design for solids handling, and keyed and secured to shaft.
7. Seal: Mechanical.
8. Motor: Hermetically sealed, capacitor-start type; with built-in overload protection; lifting eye or lug; and three-conductor, waterproof power cable of length required and with grounding plug and cable-sealing assembly for connection at pump.
   a. Motor Housing Fluid: Air.
9. Controls:
   a. Enclosure: NEMA 250, Type 1.
   b. Switch Type: Pedestal-mounted float switch with float rods and rod buttons.
   c. Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
   d. Float Guides: Pipe or other restraint for floats and rods in basins of depth greater than 60 inches.
   e. High-Water Alarm: Cover-mounted, compression-probe alarm, with electric bell; 120-V ac, with transformer and contacts for remote alarm bell.
10. Controls:
    a. Enclosure: NEMA 250, Type 1; wall-mounted.
    b. Switch Type: Mercury-float type, in NEMA 250, Type 6 enclosures with mounting rod and electric cables.
    c. Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
    d. High-Water Alarm: Rod-mounted, NEMA 250, Type 6 enclosure with mercury-float switch matching control and electric bell; 120-V ac, with transformer and integral alarm bell, with silence switch.
11. Control-Interface Features:
    b. Building Automation System Interface: Auxiliary contacts in pump controls for interface to building automation system and capable of providing the following:
       1) On-off status of pump.
       2) Alarm status.
B. Submersible, Quick-Disconnect, Double-Seal Sewage Pumps:
1. Guide-Rail Supports:
   b. Guide Rails: Vertical pipes or structural members, made of galvanized steel or other corrosion-resistant metal, attached to baseplate and basin sidewall or cover.
   c. Baseplate: Corrosion-resistant metal plate, attached to basin floor, supporting guide rails and stationary elbow.
d. Pump Yoke: Motor-mounted or casing-mounted yokes or other attachments for aligning pump during connection of flanges.

e. Movable Elbow: Pump discharge-elbow fitting with flange, seal, and positioning device.

f. Stationary Elbow: Fixed discharge-elbow fitting with flange that mates to movable-elbow flange and support attached to baseplate.

g. Lifting Cable: Stainless steel; attached to pump and cover at manhole.

C. Capacities and Characteristics:

1. See schedule on drawings.

2.2 SEWAGE-PUMP BASINS AND BASIN COVERS

A. Basins: Factory-fabricated, watertight, cylindrical, basin sump with top flange and sidewall openings for pipe connections.


2. Reinforcement: Mounting plates for pumps, fittings, guide-rail supports if used, and accessories.

3. Anchor Flange: Same material as or compatible with basin sump, cast in or attached to sump, in location and of size required to anchor basin in concrete slab.

B. Basin Covers: Fabricate metal cover with openings having gaskets, seals, and bushings; for access to pumps, pump shafts, control rods, discharge piping, vent connections, and power cables.

1. Reinforcement: Steel or cast iron, capable of supporting foot traffic for basins installed in foot-traffic areas.

C. Capacities and Characteristics:

1. See drawings for details and requirements.

2.3 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 22 05 13 "Common Motor Requirements for Plumbing 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.

B. Motors for submersible pumps shall be hermetically sealed.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Excavation and filling are specified in Section 31 20 00"Earth Moving."
3.2 INSTALLATION

A. Pump Installation Standard: Comply with HI 1.4 for installation of centrifugal pumps.

END OF SECTION 22 13 29
SECTION 22 14 13 - FACILITY STORM DRAINAGE PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Pipe, tube, and fittings.
   2. Specialty pipe fittings.

B. Related Section:
   1. Section 33 41 00 "Storm Utility Drainage Piping" for storm drainage piping outside the building.

1.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Storm drainage piping and support and installation shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1.3 ACTION SUBMITTALS

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

B. LEED Submittals:
   1. Product Data for Credit IEQ 4.1: For solvent cements and adhesive primers, documentation including printed statement of VOC content.
   2. Laboratory Test Reports for Credit IEQ 4: For solvent cements and adhesive primers, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

1.4 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For storm drainage piping, accessories, and components, from manufacturer.

B. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Piping materials shall bear label, stamp, or other markings of specified testing agency.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

A. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

2.2 HUBLESS, CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: ASTM A 888 or CISPI 301.

B. CISPI, Hubless-Piping Couplings:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. ANACO-Husky.
      c. Fernco Inc.
      d. Matco-Norca.
      e. MIFAB, Inc.
      f. Mission Rubber Company, LLC; a division of MCP Industries.
      g. Stant.
      h. Tyler Pipe; a subsidiary of McWane Inc.
   3. Description: Stainless-steel corrugated shield with stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop.

2.3 PVC PIPE AND FITTINGS

A. Solid-Wall PVC Pipe: ASTM D 2665, drain, waste, and vent.

B. PVC Socket Fittings: ASTM D 2665, made to ASTM D 3311, drain, waste, and vent patterns and to fit Schedule 40 pipe.

C. Adhesive Primer: ASTM F 656.
   1. Adhesive primer shall have a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   2. Adhesive primer shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

D. Solvent Cement: ASTM D 2564.
   1. PVC solvent cement shall have a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   2. Solvent cement shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
2.4 SPECIALTY PIPE FITTINGS

A. Transition Couplings:

1. General Requirements: Fitting or device for joining piping with small differences in OD's or of different materials. Include end connections same size as and compatible with pipes to be joined.
2. Fitting-Type Transition Couplings: Manufactured piping coupling or specified-piping-system fitting.
3. Unshielded, Nonpressure Transition Couplings:

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

      2) Fernco Inc.
      3) Mission Rubber Company, LLC; a division of MCP Industries.
      4) Plastic Oddities.

   c. Description: Elastomeric, sleeve-type, reducing or transition pattern. Include shear ring and corrosion-resistant-metal tension band and tightening mechanism on each end.
   d. Sleeve Materials:

      2) For Plastic Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
      3) For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.

4. Shielded, Nonpressure Transition Couplings:

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

      2) Mission Rubber Company, LLC; a division of MCP Industries.

   c. Description: Elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.

PART 3 - EXECUTION

3.1 EARTH MOVING

A. Comply with requirements for excavating, trenching, and backfilling specified in Section 31 20 00 "Earth Moving."

3.2 PIPING INSTALLATION

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

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

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

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

E. Install piping at indicated slopes.

F. Install piping free of sags and bends.

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

H. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices specified in Section 22 05 48 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

I. Make changes in direction for storm drainage piping using appropriate branches, bends, and long-sweep bends. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.

J. Lay buried building storm drainage piping beginning at low point of each system. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements. Maintain swab in piping and pull past each joint as completed.

K. Install storm drainage piping at the following minimum slopes unless otherwise indicated:

1. Building Storm Drain: 1 percent downward in direction of flow for piping NPS 3 and smaller; 1 percent downward in direction of flow for piping NPS 4 and larger.
2. Horizontal Storm-Drainage Piping: 2 percent downward in direction of flow.

L. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."

   1. Install encasement on underground piping according to ASTM A 674 or AWWA C105.

M. Install aboveground ABS piping according to ASTM D 2661.

N. Install aboveground PVC piping according to ASTM D 2665.

O. Plumbing Specialties:

   1. Install cleanouts at grade and extend to where building storm drains connect to building storm sewers in storm drainage gravity-flow piping. Install cleanout fitting with closure plug inside the building in storm drainage force-main piping. Comply with requirements for cleanouts specified in Section 22 14 23 "Storm Drainage Piping Specialties."
   2. Install drains in storm drainage gravity-flow piping. Comply with requirements for drains specified in Section 22 14 23 "Storm Drainage Piping Specialties."
P. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

Q. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 22 05 17 "Sleeves and Sleeve Seals for Plumbing Piping."

R. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 22 05 17 "Sleeves and Sleeve Seals for Plumbing Piping."

S. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 22 05 18 "Escutcheons for Plumbing Piping."

3.3 JOINT CONSTRUCTION

A. Join hubless, cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-piping coupling joints.

3.4 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements for seismic-restraint devices specified in Section 22 05 48 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

B. Comply with requirements for pipe hanger and support devices and installation specified in Section 22 05 29 "Hangers and Supports for Plumbing Piping and Equipment."

1. Vertical Piping: MSS Type 8 or Type 42, clamps.
2. Individual, Straight, Horizontal Piping Runs:
   a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
   b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
   c. Longer Than 100 Feet if Indicated: MSS Type 49, spring cushion rolls.

3. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
4. Base of Vertical Piping: MSS Type 52, spring hangers.

C. Support horizontal piping and tubing within 12 inches of each fitting and coupling.

D. Support vertical piping and tubing at base and at each floor.

E. Rod diameter may be reduced one size for double-rod hangers, with 3/8-inch minimum rods.

F. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 1-1/2 and NPS 2: 60 inches with 3/8-inch rod.
   2. NPS 3: 60 inches with 1/2-inch rod.
   3. NPS 4 and NPS 5: 60 inches with 5/8-inch rod.
   4. NPS 6 and NPS 8: 60 inches with 3/4-inch rod.
   5. Spacing for 10-foot pipe lengths may be increased to 10 feet. Spacing for fittings is limited to 60 inches.
G. Install supports for vertical cast-iron soil piping every 15 feet.

H. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 1-1/2 and NPS 2: 96 inches with 3/8-inch rod.
   2. NPS 2-1/2: 108 inches with 1/2-inch rod.
   3. NPS 3 to NPS 5: 10 feet with 1/2-inch rod.
   4. NPS 6: 10 feet with 5/8-inch rod.

I. Install supports for vertical copper tubing every 10 feet.

J. Install hangers for PVC piping with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 1-1/2 and NPS 2: 48 inches with 3/8-inch rod.
   2. NPS 3: 48 inches with 1/2-inch rod.
   3. NPS 4 and NPS 5: 48 inches with 5/8-inch rod.
   4. NPS 6 and NPS 8: 48 inches with 3/4-inch rod.

K. Install supports for vertical PVC piping every 48 inches.

L. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.

3.5 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect interior storm drainage piping to exterior storm drainage piping. Use transition fitting to join dissimilar piping materials.

C. Connect storm drainage piping to roof drains and storm drainage specialties.
   1. Install test tees (wall cleanouts) in conductors near floor, and floor cleanouts with cover flush with floor.

D. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.

3.6 IDENTIFICATION

A. Identify exposed storm drainage piping. Comply with requirements for identification specified in Section 22 05 53 "Identification for Plumbing Piping and Equipment."

3.7 FIELD QUALITY CONTROL

A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.
   1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in.
2. **Final Inspection:** Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

   **B. Reinspection:** If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.

   **C. Reports:** Prepare inspection reports and have them signed by authorities having jurisdiction.

   **D. Test storm drainage piping according to procedures of authorities having jurisdiction.**

### 3.8 CLEANING

**A.** Clean interior of piping. Remove dirt and debris as work progresses.

**B.** Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.

**C.** Place plugs in ends of uncompleted piping at end of day and when work stops.

### 3.9 PIPING SCHEDULE

**A.** Flanges and unions may be used on aboveground pressure piping unless otherwise indicated.

**B.** Aboveground, soil and waste piping NPS 8 and smaller shall be any of the following (if piping is located in a ceiling plenum, utilize cast iron piping only):

1. Hubless, cast-iron soil pipe and fittings; CISPI hubless-piping couplings; and coupled joints.
2. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints.

**C.** Aboveground, vent piping NPS 6 and smaller shall be any of the following (If piping is located in a ceiling plenum, utilize cast iron piping only):

1. Hubless, cast-iron soil pipe and fittings; CISPI hubless-piping couplings; and coupled joints.
2. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints.

**D.** Underground, soil, waste, and vent piping NPS 8 and smaller shall be any of the following:

1. Hubless, cast-iron soil pipe and fittings; CISPI hubless-piping couplings; and coupled joints.
2. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints.

END OF SECTION 22 14 13
SECTION 22 14 23 - STORM DRAINAGE PIPING SPECIALTIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Roof drains.
   2. Miscellaneous storm drainage piping specialties.
   3. Cleanouts.
   4. Flashing materials.

1.2 ACTION SUBMITTALS

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

1.3 QUALITY ASSURANCE

A. Drainage piping specialties shall bear label, stamp, or other markings of specified testing agency.

PART 2 - PRODUCTS

2.1 METAL ROOF DRAINS

A. Cast-Iron, Large-Sump, General-Purpose Roof Drains:
   2. Body Material: Cast iron.
   3. Dimension of Body: Nominal 14-inch diameter.
   4. Combination Flashing Ring and Gravel Stop: Required.
   5. Outlet: Bottom.
   7. Underdeck Clamp: Required.
   11. Water Dam: Provide where scheduled.

2.2 MISCELLANEOUS STORM DRAINAGE PIPING SPECIALTIES

A. Downspout Adaptors:
   1. Description: Manufactured, gray-iron casting, for attaching to horizontal-outlet, parapet roof drain and to exterior, sheet metal downspout.
   2. Size: Inlet size to match parapet drain outlet.
2.3 CLEANOUTS

A. Floor Cleanouts:

1. Standard: ASME A112.36.2M, for adjustable housing cleanouts.
2. Size: Same as connected branch.
3. Type: Adjustable housing.
4. Body or Ferrule Material: Cast iron.
5. Closure: Brass plug with straight threads and gasket.
6. Adjustable Housing Material: Cast iron with.
8. Frame and Cover Shape: Round.
10. Riser: ASTM A 74, Service class, cast-iron drainage pipe fitting and riser to cleanout.

B. Test Tees:

1. Standard: ASME A112.36.2M and ASTM A 74, ASTM A 888, or CISPI 301, for cleanout test tees.
2. Size: Same as connected drainage piping.
5. Closure Plug Size: Same as or not more than one size smaller than cleanout size.

C. Wall Cleanouts:

1. Standard: ASME A112.36.2M, for cleanouts. Include wall access.
2. Size: Same as connected drainage piping.
3. Body Material: Hubless, cast-iron soil-pipe test tee as required to match connected piping.
4. Closure: Countersunk or raised-head, brass plug.
5. Closure Plug Size: Same as or not more than one size smaller than cleanout size.

2.4 FLASHING MATERIALS

A. Copper Sheet: ASTM B 152/B 152M, 12 oz./sq. ft..

B. Zinc-Coated Steel Sheet: ASTM A 653/A 653M, with 0.20 percent copper content and 0.04-inch minimum thickness unless otherwise indicated. Include G90 hot-dip galvanized, mill-phosphatized finish for painting if indicated.


D. Fasteners: Metal compatible with material and substrate being fastened.

E. Metal Accessories: Sheet metal strips, clamps, anchoring devices, and similar accessory units required for installation; matching or compatible with material being installed.
F. Solder: ASTM B 32, lead-free alloy.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install roof drains at low points of roof areas according to roof membrane manufacturer’s written installation instructions.

1. Install flashing collar or flange of roof drain to prevent leakage between drain and adjoining roofing. Maintain integrity of waterproof membranes where penetrated.
2. Install expansion joints, if indicated, in roof drain outlets.
3. Position roof drains for easy access and maintenance.

B. Install downspout adapters on outlet of back-outlet parapet roof drains and connect to sheet metal downspouts.

C. Install conductor nozzles at exposed bottom of conductors where they spill onto grade.

D. Install cleanouts in aboveground piping and building drain piping according to the following instructions unless otherwise indicated:

1. Use cleanouts the same size as drainage piping up to NPS 4. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
2. Locate cleanouts at each change in direction of piping greater than 45 degrees.
3. Locate cleanouts at minimum intervals of 50 feet for piping NPS 4 and smaller and 100 feet for larger piping.
4. Locate cleanouts at base of each vertical soil and waste stack.

E. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.

F. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.

G. Install test tees in vertical conductors and near floor.

H. Install wall cleanouts in vertical conductors. Install access door in wall if indicated.

I. Install sleeve flashing device with each conductor passing through floors with waterproof membrane.

3.2 CONNECTIONS

A. Comply with requirements for piping specified in Section 22 14 13 "Facility Storm Drainage Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

3.3 FLASHING INSTALLATION

A. Fabricate flashing from single piece of metal unless large pans, sumps, or other drainage shapes are required. Join flashing according to the following if required:
1. Lead Sheets: Burn joints of 6.0-lb/sq. ft. lead sheets, 0.0938-inch thickness or thicker. Solder joints of 4.0-lb/sq. ft. lead sheets, 0.0625-inch thickness or thinner.
2. Copper Sheets: Solder joints of copper sheets.

B. Install sheet flashing on pipes, sleeves, and specialties passing through or embedded in floors and roofs with waterproof membrane.

1. Pipe Flashing: Sleeve type, matching the pipe size, with a minimum length of 10 inches and with skirt or flange extending at least 8 inches around pipe.
2. Sleeve Flashing: Flat sheet, with skirt or flange extending at least 8 inches around sleeve.
3. Embedded Specialty Flashing: Flat sheet, with skirt or flange extending at least 8 inches around specialty.

C. Set flashing on floors and roofs in solid coating of bituminous cement.

D. Secure flashing into sleeve and specialty clamping ring or device.

E. Fabricate and install flashing and pans, sumps, and other drainage shapes.

3.4 PROTECTION

A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.

B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION 22 14 23
SECTION 22 15 13 - GENERAL-SERVICE COMPRESSED-AIR PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes piping and related specialties for general-service compressed-air systems operating at 150 psig or less.

B. See Section 22 15 19 "General-Service Packaged Air Compressors and Receivers" for general-service air compressors and accessories.

1.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Compressed-air piping and support and installation shall withstand effects of seismic events determined according to SEI/ASCE 7, "Minimum Design Loads for Buildings and Other Structures."

1.3 ACTION SUBMITTALS

A. Product Data: For the following:
   1. Pressure regulators. Include rated capacities and operating characteristics.
   2. Automatic drain valves.
   3. Filters. Include rated capacities and operating characteristics.
   4. Lubricators. Include rated capacities and operating characteristics.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control test reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.6 QUALITY ASSURANCE

PART 2 - PRODUCTS

2.1 PIPES, TUBES, AND FITTINGS

A. Copper Tube: ASTM B 88, Type K or L seamless, drawn-temper, water tube.
   1. Wrought-Copper Fittings: ASME B16.22, solder-joint pressure type or MSS SP-73, wrought copper with dimensions for brazed joints.
   2. Cast-Copper-Alloy Flanges: ASME B16.24, Class 150 or 300.
   3. Copper Unions: ASME B16.22 or MSS SP-123.

B. Transition Couplings for Metal Piping: Metal coupling or other manufactured fitting same size as, with pressure rating at least equal to and ends compatible with, piping to be joined.

2.2 JOINING MATERIALS

A. Pipe-Flange Gasket Materials: Suitable for compressed-air piping system contents.
   1. ASME B16.21, nonmetallic, flat, full-face, asbestos free, 1/8-inch maximum thickness.

B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

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

D. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated.

2.3 VALVES

A. Metal Ball, Butterfly, Check, and Gate Valves: Comply with requirements in Section 22 05 23.12 "Ball Valves for Plumbing Piping," Section 22 05 23.13 "Butterfly Valves for Plumbing Piping," Section 22 05 23.14 "Check Valves for Plumbing Piping," and Section 22 05 23.15 "Gate Valves for Plumbing Piping."

2.4 DIELECTRIC FITTINGS

A. General Requirements for Dielectric Fittings: Combination fitting of copper alloy and ferrous materials with insulating material; suitable for system fluid, pressure, and temperature. Include threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.

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

2.5 FLEXIBLE PIPE CONNECTORS

A. Bronze-Hose Flexible Pipe Connectors: Corrugated-bronze tubing with bronze wire-braid covering and ends brazed to inner tubing.
2. End Connections, NPS 2 and Smaller: Threaded copper pipe or plain-end copper tube.
3. End Connections, NPS 2-1/2 and Larger: Flanged copper alloy.

B. Stainless-Steel-Hose Flexible Pipe Connectors: Corrugated-stainless-steel tubing with stainless-steel wire-braid covering and ends welded to inner tubing.
   2. End Connections, NPS 2 and Smaller: Threaded steel pipe nipple.
   3. End Connections, NPS 2-1/2 and Larger: Flanged steel nipple.

2.6 SPECIALTIES

A. Safety Valves: ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," construction; National Board certified, labeled, and factory sealed; constructed of bronze body with poppet-type safety valve for compressed-air service.
   1. Pressure Settings: Higher than discharge pressure and same or lower than receiver pressure rating.

B. Air-Main Pressure Regulators: Bronze body, pilot-operated direct acting, spring-loaded manual pressure-setting adjustment, and rated for 250-psig inlet pressure, unless otherwise indicated.

C. Air-Line Pressure Regulators: Diaphragm or pilot operated, bronze body, direct acting, spring-loaded manual pressure-setting adjustment, and rated for 200-psig minimum inlet pressure, unless otherwise indicated.

D. Automatic Drain Valves: Stainless-steel body and internal parts, rated for 200-psig minimum working pressure, capable of automatic discharge of collected condensate. Include mounting bracket if wall mounting is indicated.

E. Coalescing Filters: Coalescing type with activated carbon capable of removing water and oil aerosols; with color-change dye to indicate when carbon is saturated and warning light to indicate when selected maximum pressure drop has been exceeded. Include mounting bracket if wall mounting is indicated.

F. Mechanical Filters: Two-stage, mechanical-separation-type, air-line filters. Equip with deflector plates, resin-impregnated-ribbon-type filters with edge filtration, and drain cock. Include mounting bracket if wall mounting is indicated.

2.7 QUICK COUPLINGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Aeroquip Corporation.
   2. Bowes Manufacturing Inc.
   3. Foster Manufacturing, Inc.
   5. Parker Hannifin Corp.
   6. Rectus Corp.
   8. TOMCO Products Inc.
B. General Requirements for Quick Couplings: Assembly with locking-mechanism feature for quick connection and disconnection of compressed-air hose.

C. Automatic-Shutoff Quick Couplings: Straight-through brass body with O-ring or gasket seal and stainless-steel or nickel-plated-steel operating parts.
   1. Socket End: With one-way valve and threaded inlet for connection to piping or threaded hose fitting.
   2. Plug End: Straight-through type with barbed outlet for attaching hose.

D. Valveless Quick Couplings: Straight-through brass body with stainless-steel or nickel-plated-steel operating parts.
   1. Socket End: With O-ring or gasket seal, without valve, and with barbed inlet for attaching hose.
   2. Plug End: With barbed outlet for attaching hose.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. Compressed-Air Piping between Air Compressors and Receivers: Use one of the following piping materials for each size range:
   1. NPS 2 and Smaller: Steel pipe; threaded, malleable-iron fittings; and threaded joints.
   2. NPS 2 and Smaller: Type K or L, copper tube; wrought-copper fittings; and brazed joints.

B. Low-Pressure Compressed-Air Distribution Piping: Use the following piping materials for each size range:
   1. NPS 2 and Smaller: Type K or L, copper tube; wrought-copper fittings; and brazed or soldered joints.

C. Drain Piping: Use the following piping materials:
   1. NPS 2 and Smaller: Type M copper tube; wrought-cooper fittings; and brazed or soldered joints.

3.2 VALVE APPLICATIONS

A. Comply with requirements in "Valve Applications" Article in Section 22 05 23.12 "Ball Valves for Plumbing Piping," Section 22 05 23.13 "Butterfly Valves for Plumbing Piping," Section 22 05 23.14 "Check Valves for Plumbing Piping," and Section 22 05 23.15 "Gate Valves for Plumbing Piping."

B. Equipment Isolation Valves: Safety-exhaust, copper-alloy ball valve with exhaust vent and pressure rating at least as great as piping system operating pressure.

3.3 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of compressed-air piping. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, air-compressor sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
B. Install piping concealed from view and protected from physical contact by building occupants, unless otherwise indicated and except in equipment rooms and service areas.

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

D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal and to coordinate with other services occupying that space.

E. Install piping adjacent to equipment and machines to allow service and maintenance.

F. Install nipples, flanges, unions, transition and special fittings, and valves with pressure ratings same as or higher than system pressure rating, unless otherwise indicated.

G. Install branch connections to compressed-air mains from top of main. Provide drain leg and drain trap at end of each main and branch and at low points.

H. Install thermometer and pressure gage on discharge piping from each air compressor and on each receiver. Comply with requirements in Section 22 05 19 "Meters and Gages for Plumbing Piping."

I. Install piping to permit valve servicing.

J. Install piping free of sags and bends.

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

L. Install seismic restraints on piping. Seismic-restraint devices are specified in Section 22 05 48 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

M. Install unions, adjacent to each valve and at final connection to each piece of equipment and machine.

N. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 22 05 17 "Sleeves and Sleeve Seals for Plumbing Piping."

O. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 22 05 17 "Sleeves and Sleeve Seals for Plumbing Piping."

P. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 22 05 18 "Escutcheons for Plumbing Piping."

3.4 JOINT CONSTRUCTION

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

B. Remove scale, slag, dirt, and debris from pipe and fittings before assembly.

C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Apply appropriate tape or thread compound to external pipe threads.

D. Brazed Joints for Copper Tubing: Join according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter.
E. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Join according to ASTM B 828 or CDA’s "Copper Tube Handbook."

F. Flanged Joints: Use asbestos-free, nonmetallic gasket suitable for compressed air. Join flanges with gasket and bolts according to ASME B31.9 for bolting procedure.

G. Dissimilar Metal Piping Material Joints: Use dielectric fittings.

3.5 VALVE INSTALLATION

A. General-Duty Valves: Comply with requirements in Section 22.05 23.12 "Ball Valves for Plumbing Piping," Section 22.05 23.13 "Butterfly Valves for Plumbing Piping," Section 22.05 23.14 "Check Valves for Plumbing Piping," and Section 22.05 23.15 "Gate Valves for Plumbing Piping."

B. Install shutoff valves and unions or flanged joints at compressed-air piping to air compressors.

C. Install shutoff valve at inlet to each automatic drain valve, filter, lubricator, and pressure regulator.

D. Install check valves to maintain correct direction of compressed-air flow to and from compressed-air piping specialties and equipment.

3.6 DIELECTRIC FITTING INSTALLATION

A. Install dielectric unions in piping at connections of dissimilar metal piping and tubing.

3.7 FLEXIBLE PIPE CONNECTOR INSTALLATION

A. Install flexible pipe connectors in discharge piping and in inlet air piping from remote air-inlet filter of each air compressor.

B. Install bronze-hose flexible pipe connectors in copper compressed-air tubing.

C. Install stainless-steel-hose flexible pipe connectors in steel compressed-air piping.

3.8 SPECIALTY INSTALLATION

A. Install safety valves on receivers in quantity and size to relieve at least the capacity of connected air compressors.

B. Install air-main pressure regulators in compressed-air piping at or near air compressors.

C. Install air-line pressure regulators in branch piping to equipment.

D. Install automatic drain valves on aftercoolers, receivers, and dryers. Discharge condensate onto nearest floor drain.

E. Install coalescing filters in compressed-air piping at or near air compressors and upstream from mechanical filters. Mount on wall at locations indicated.
F. Install mechanical filters in compressed-air piping at or near air compressors and downstream from coalescing filters. Mount on wall at locations indicated.

G. Install quick couplings at piping terminals for hose connections.

H. Install hose assemblies at hose connections.

3.9 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements in Section 22 05 48 "Vibration and Seismic Controls for Plumbing Piping and Equipment" for seismic-restraint devices.

B. Comply with requirements in Section 22 05 29 "Hangers and Supports for Plumbing Piping and Equipment" for pipe hanger and support devices.

C. Vertical Piping: MSS Type 8 or 42, clamps.

D. Individual, Straight, Horizontal Piping Runs:
   1. 100 Feet or Less: MSS Type 1, adjustable, steel clevis hangers.
   2. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.

E. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.

F. Base of Vertical Piping: MSS Type 52, spring hangers.

G. Support horizontal piping within 12 inches of each fitting and coupling.

H. Rod diameter may be reduced 1 size for double-rod hangers, with 3/8-inch minimum rods.

I. Install hangers for Schedule 40, steel piping with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 1/4 to NPS 1/2: 96 inches with 3/8-inch rod.
   2. NPS 3/4 to NPS 1-1/4: 84 inches with 3/8-inch rod.
   3. NPS 1-1/2: 12 feet with 3/8-inch rod.
   4. NPS 2: 13 feet with 3/8-inch rod.

J. Install supports for vertical, Schedule 40, steel piping every 15 feet.

K. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 1/4: 60 inches with 3/8-inch rod.
   2. NPS 3/8 and NPS 1/2: 72 inches with 3/8-inch rod.
   4. NPS 1: 96 inches with 3/8-inch rod.
   6. NPS 1-1/2: 10 feet with 3/8-inch rod.
   7. NPS 2: 11 feet with 3/8-inch rod.

L. Install supports for vertical copper tubing every 10 feet.
3.10 LABELING AND IDENTIFICATION

A. Install identifying labels and devices for general-service compressed-air piping, valves, and specialties. Comply with requirements in Section 22 05 53 "Identification for Plumbing Piping and Equipment."

3.11 FIELD QUALITY CONTROL

A. Perform field tests and inspections.

B. Tests and Inspections:

1. Piping Leak Tests: Test new and modified parts of existing piping. Cap and fill general-service compressed-air piping with oil-free dry air or gaseous nitrogen to pressure of 50 psig above system operating pressure, but not less than 150 psig. Isolate test source and let stand for four hours to equalize temperature. Refill system, if required, to test pressure; hold for two hours with no drop in pressure.

2. Repair leaks and retest until no leaks exist.

3. Inspect filters and pressure regulators for proper operation.

END OF SECTION 22 15 13
SECTION 22 15 19 - GENERAL-SERVICE PACKAGED AIR COMPRESSORS AND RECEIVERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Oil-flooded, rotary-screw air compressors.
   2. Inlet-air filters.
   3. Refrigerant compressed-air dryers.

1.2 DEFINITIONS

A. Actual Air: Air delivered from air compressors. Flow rate is delivered compressed air measured in acfm.
B. Standard Air: Free air at 68 deg F and 1 atmosphere before compression or expansion and measured in scfm.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.
B. Shop Drawings: Diagrams for power, signal, and control wiring.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 GENERAL

A. The air compressor is a VS 25 single stage, oil flooded, rotary screw type, air or water-cooled compressor utilizing an integrated variable speed drive control. At full load, the compressor capacity is 110 (3.12) ACFM (m³/min) at a discharge pressure of 125 (8.6) PSIG (bar). Capacity is the actual CFM at inlet conditions, delivered at the final discharge of the compressor package. The capacity will vary based upon system demand and will range from 100% to 20% of full capacity over a pressure range of 70 to 175 PSIG. The unit is completely assembled and factory tested under full load and part load conditions.
2.2 INLET AIR FILTER

A. Ambient air is directed inside the enclosure to a radial seal type air filter. The element is rated 99.9% efficient at 3.0 micron. This inlet filter arrangement provides clean air for compression in normal industrial applications.

2.3 AIREND

A. The airend is critical to the reliability and efficiency of the compressor and has been optimized to ensure superior efficiency throughout a wide capacity range. To ensure volumetric efficiency and finite tolerance control, the rotors are manufactured in multiple steps of high-precision milling and grinding. The airend housings are manufactured utilizing precision CNC machining centers to provide precise tolerance control and to obtain mechanical alignment with the rotor set.

B. All bearings are designed for long life and reliability. A large ball bearing coupled with a cylindrical roller bearing is used at the thrust end of each rotor in the airend. These premium quality bearings are designed to carry both radial and thrust loading by utilizing their combined strengths of the bearings. The cylindrical roller inlet bearings carry radial loading.

2.4 MOTOR

A. The compressor drive motor is a 25 kW inverter-duty motor and utilizes a Pulse Width Modulation inverter to control its starting, frequency and speed. The motor optimizes torque, efficiency and power factor through the following features:

1. Unlimited number of starts/stops per hour and precise variable speed control to accurately match air demand changes.
2. Premium 95% efficiency.
3. A 1.0 service factor and increased air gaps allow cooler operating temperatures with an ambient rating of 115°F (46°C).
4. Direct, flange mounting of the motor to the airend maintains near perfect alignment. The motor shaft is coupled to the airend shaft via a flexible, dropout style coupling.

B. In summary, the design of this motor to perfectly meet the specific requirements of the airend and the motor's direct mounting to the airend increase efficiency and reliability by eliminating energy robbing components and by significantly reducing the number of serviceable parts.

2.5 INVERTER DRIVE

A. The package has a standard integral Pulse Width Modulation inverter. The inverter is a standard type with a minimum efficiency of 97%. The drive, which is programmed with firmware at the time of shipment, communicates with the AirSmart™ controller for control of the unit. The combination of the AirSmart controller and the drive/motor/airend combination allows the compressor package to be the most flexible and energy efficient in today's market.

2.6 BASEPLATE

A. The fabricated steel base is manufactured to provide maximum rigidity and minimizes sound levels. The base is sufficient for final installation (see floor and mounting loads), no need for special foundations.
2.7 ENCLOSURE

A. A very low sound level of 66 dBA (per ISO 2151) is achieved through the use of an engineered sound enclosure. The enclosure is designed with hinged/removable doors that allow for easy access and servicing of all internal components. Powder coat paint is externally applied via an electrostatic coating process to a minimum thickness of 50μm. All coatings must meet Gardner Denver’s rigorous painting specification requirements.

2.8 COOLANT/FILTRATION

A. Coolant filtration is accomplished by a 25-micron rated, spin-on-type filter. Filter condition is monitored by the AirSmart controller, which provides a warning when filter reaches the pre-determined operational hours. The controller will keep track of the number of hours remaining on the filter before it needs to be changed. When the advisory displays on the screen it will indicate the part number of filter. The system contains an internal pressure relief valve that bypasses at 2 to 2.5 bar differential pressure. This protects the compressor in the event of the oil filter plugging or upon cold starts that cause a high differential.

2.9 COOLANT/AIR SEPARATION

A. Efficient separation of coolant and air is critical in establishing the level of air quality at the compressor package discharge. The TEMPEST® unit integrates the air end and a high efficiency, leak free coolant separation system to ensure low oil-carryover. Coolant separation in the unit is made in three stages. First, most of the coolant is separated by gravity and centrifugal force against the bottom of the TEMPEST® unit. Second, separation is made by centrifugal force in the cyclone and is finally lead to separation element.

B. The TEMPEST® unit is rated at 13.5 bar (200 psig) and all the units have been tested under 21 bar (300 psig) pressure. The vessel meets all of the requirements of PED and has a nameplate indicating compliance.

C. The TEMPEST® unit incorporates an easy open chamber, which allows direct access to change the separator element. Consequently, separator element changes are simple and quick.

2.10 SEPARATOR ELEMENT

A. The third stage in the separation of coolant and air occurs at the separator element. The element is a unitized element with pleated media and an inside-out separation design. The coolant scavenge line is an integral part of the TEMPEST® unit. This eliminates the potential of incorrect re-assembly when the element is serviced. Coolant carry-over will be 2 ppm or less using the ISO 8573-2 test method.

2.11 HEAT EXCHANGERS

A. Air-cooled, single pass, radiator-type heat exchanger is mounted horizontally at the top of the compressor package. The heat exchanger is constructed of high strength aluminum and is designed to efficiently reject the heat of compression in ambient temperatures as high as 46°C (115°F) with a CTD of 8°C (15°F). Airflow through the coolers is managed by an axial fan, which pushes an even disbursement of cooling air across the entire surface of the heat exchanger core.
2.12 TEMPERATURE CONTROL BY OIL MIXING VALVE

A. Accurate temperature control is important to avoid condensate in the coolant and prevent overheating under harsh ambient conditions. Compressor coolant temperature is regulated by a unique oil-mixing valve, which directs the coolant either through the heat exchanger or directly to the coolant injection of the airend. An algorithm in the AirSmart controller controls the electronic oil-mixing valve.

2.13 CONTROL METHODOLOGY

A. The compressor is controlled via the AirSmart controller. This microprocessor allows for turndown range of 100 - 20% (depending upon the model and discharge pressure) of package capacity at a system efficiency of 92% or greater. Below the minimum turndown, the control methodology stops the compressor. The compressor package can start against load. This eliminates the loss of energy from fully blowing down the system. The compressor has the ability to start under a load and as often as required without damage to the drive and/or motor. The compressor will stop when minimum speed is reached at the unload pressure setting. The compressor will remain off until system pressure decays below the load pressure at which time the compressor will restart. The controller methodology is to operate at the lowest possible specific power throughout the entire pressure and turndown range.

2.14 MICROPROCESSOR CONTROLS

A. The exclusive AirSmart controller manages control of the compressor. This comprehensive control system includes safety controls, operational instruction, data feedback, capacity control, operational control, maintenance and service information, and inverter interface. All information is displayed for the user at a LCD control center. Information Displays include the following:

<table>
<thead>
<tr>
<th>MAINTENANCE INFO DISPLAY</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Total Hours</td>
<td>Displays the total number of operational hours of the unit.</td>
</tr>
<tr>
<td>• Load Hours</td>
<td>Displays the total number of hours the unit has been load-ed.</td>
</tr>
<tr>
<td>• Next Oil Filter</td>
<td>Displays the number of hours until the next oil filter element change is required.</td>
</tr>
<tr>
<td>• Next Oil Change</td>
<td>Displays the number of hours until the next oil change is required.</td>
</tr>
<tr>
<td>• Next Oil Separator</td>
<td>Displays the number of hours until the next air/oil separator element change is required.</td>
</tr>
<tr>
<td>• Next Air Filter</td>
<td>Displays the number of hours until the next air filter element change is required.</td>
</tr>
<tr>
<td>• Next Control Box Filter</td>
<td>Displays the number of hours until the next control box filter element change is required.</td>
</tr>
<tr>
<td>• Next Motor Lube</td>
<td>Displays the number of hours until the next motor bearing lubrication is required.</td>
</tr>
<tr>
<td>• Start Timer</td>
<td>Displays the set time of the start timer. When the unit is started, the controller will keep the unit at minimum speed until the timer times out and the control pressure is reached to allow the inlet valve to open and begin compressing air.</td>
</tr>
<tr>
<td>• Blowdown Timer</td>
<td>Displays the set time of the blowdown timer. This timer starts timing when the unit reaches unload pressure, minimum speed and the compressor stops. When the timer expires it allows the reservoir to blowdown to zero pressure.</td>
</tr>
<tr>
<td>• Auto Timer</td>
<td>Displays the set time of the auto timer. This timer starts</td>
</tr>
<tr>
<td>Feature</td>
<td>Description</td>
</tr>
<tr>
<td>----------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Average Capacity (CFM)</td>
<td>Displays the average capacity in CFM over the last hour of operation.</td>
</tr>
<tr>
<td>Average Capacity (%)</td>
<td>Displays the average capacity in percent of full capacity over the last hour of operation.</td>
</tr>
<tr>
<td>Average Package Power</td>
<td>Displays the average package power consumed in kilowatts over the last hour of operation.</td>
</tr>
<tr>
<td>Energy Cost</td>
<td>Displays the current energy cost in dollars (or Euros) based on operator-defined price per kilowatt-hour.</td>
</tr>
<tr>
<td>Total Cost</td>
<td>Displays the accumulated energy cost of the package for an operator-defined period of time.</td>
</tr>
<tr>
<td>Firmware Version</td>
<td>Displays the version of the firmware currently loaded into the controller.</td>
</tr>
<tr>
<td>Model Table Version</td>
<td>Displays the version of the model table currently loaded into the controller.</td>
</tr>
<tr>
<td>Language Table Version</td>
<td>Displays the version of the language table currently loaded into the controller.</td>
</tr>
<tr>
<td>Motor Current</td>
<td>Displays the amperage draw of the drive motor.</td>
</tr>
<tr>
<td>Motor Power</td>
<td>Displays the kW draw of the drive motor.</td>
</tr>
<tr>
<td>Motor Voltage</td>
<td>Displays the AC voltage level delivered to the drive motor.</td>
</tr>
<tr>
<td>Motor Speed</td>
<td>Displays the rpm of the drive motor.</td>
</tr>
<tr>
<td>Motor Frequency</td>
<td>Displays the frequency (Hz) of the drive motor.</td>
</tr>
<tr>
<td>Inlet Temperature</td>
<td>Displays the current ambient temperature outside of the compressor package.</td>
</tr>
<tr>
<td>Discharge Temperature</td>
<td>Displays the temperature at the discharge of the compressor prior to entering the air/coolant reservoir.</td>
</tr>
<tr>
<td>Reservoir Pressure</td>
<td>Displays the pressure on the “wet side” of the air/oil separator element.</td>
</tr>
<tr>
<td>Plant Pressure</td>
<td>Displays the system pressure at the aftercooler discharge into the plant system.</td>
</tr>
<tr>
<td>Dryer Temperature</td>
<td>Displays the air temperature entering the integrated dryer, if so equipped.</td>
</tr>
<tr>
<td>Advisory History 1 - 6</td>
<td>Displays the last six advisory issues for the unit. The pressure, temperature, motor amps, motor power, motor speed, etc. data recordings are saved at each advisory.</td>
</tr>
<tr>
<td>Shutdown History 1 – 6</td>
<td>Displays the last six shutdown issues for the unit. The pressure, temperature, motor amps, motor power, motor speed, etc. data recordings are saved at each shutdown.</td>
</tr>
<tr>
<td>V Freq. CMD</td>
<td>Displays the controller’s commanded motor frequency (Hz) value of the drive motor.</td>
</tr>
<tr>
<td>V DC</td>
<td>Displays the DC buss voltage value of the drive motor.</td>
</tr>
<tr>
<td>V TEMPERATURE</td>
<td>Displays the temperature of the drive heat sink.</td>
</tr>
</tbody>
</table>
**Drive Fault**
- Displays the fault value of the drive, if one should occur.
- If there is a zero next to the drive number there is no current fault. If there is a number, the number will correspond to a specific fault.
- For a list of fault codes and their description refer to the Drives User Manual.

**Drive Firmware Version**
- Displays the current firmware version of the drive.

### Diagnostic Info Display

- **V Calc Min**
  - Displays the minimum speed of the drive motor.

- **V Calc Max**
  - Displays the maximum speed of the drive motor.

- **Target Temperature**
  - Displays the target temperature the aftercooler fan is attempting to maintain.

- **Oil Valve Cmd**
  - Displays the percentage of lubricant flow being directed to the bypass vs. the cooler.

### Service Menu Tree

**Operational Adjustments**

- **Language**
  - Allows the operator to select the language of the controller. The operator can select from 8 languages.

- **Target Pressure**
  - Allows the operator to adjust the target pressure that is to be maintained at the package discharge.

- **Unload Pressure**
  - Allows the operator to adjust the pressure at which the unit will unload. It can be set no less than the Target Pressure + 5 PSIG. It can be set as high as 180 psig.

- **Load Pressure**
  - Allows the operator to adjust the pressure that the compressor will load again after it has unloaded and/or stopped. This pressure can be as low as 30 PSIG but no higher than the Target Pressure.

- **Pressure Units of Measure**
  - This setpoint allows you to choose the pressure units you wish to see displayed. These include the following: PSI, BAR, kPa, kg/cm².

- **Temperature Units of Measure**
  - Allows the operator to select between Centigrade (metric) and Fahrenheit (English).

- **Operating Mode**
  - Automatic/Constant/Sequence
    - **Automatic**—Normal variable speed operation, motor will stop after unload. If the Auto Timer is programmed for 10 minutes, the compressor motor will stop if the unit runs unloaded for 10 minutes. If the Auto Timer is programmed for 0 minutes the compressor motor will stop as soon as the unit unloads.
    - **Constant**—Normal variable speed operation, motor will NOT stop after unload. Machine continues to run unloaded at minimum speed.
    - **Sequence**—Modulation is controlled by the communications module.

- **Start Timer**
  - The time entered will dictate the time the compressor runs at minimum speed before it goes to maximum speed or to the speed that is required to reach target pressure.
  - NOTE: The compressor will not run at full speed until the control pressure has reached 60 psig.
This timer is adjustable from 0 to 600 seconds.

The compressor is capable of reaching maximum speed within 5 seconds after the run button has been pressed.

**Stop Timer**

The time entered will dictate the time between the stop button being pushed or activated and the motor stopping.

When the Stop button is pushed or remotely activated the motor will go to minimum speed, and the compressor will blow down, then the motor will stop when this stop timer has counted down to zero.

This timer is adjustable from 0 and 120 seconds. The default time for the Stop Timer is 0.

**Blowdown Timer**

The time entered will dictate the time the unit will wait before blowdown after the unit has stopped.

The blowdown timer is adjustable from 1 to 1,200 seconds.

The unit will blow down immediately if the stop button has been pushed or the unit has shutdown due to a fault or an exceeded parameter.

The default set-time for the blowdown timer is zero.

**Blowdown Counter**

The value entered will dictate the number of blowdown cycles the unit can perform in a given period of time. Note: the blowdown cycle time is controlled by the blowdown timer.

**Auto Timer**

This is the amount of time the unit will run unloaded before the compressor motor will stop.

If the Auto Timer is programmed for 10 minutes, the compressor motor will stop after the unit runs unloaded for 10 minutes.

If the Auto Timer is programmed for 0 minutes the compressor motor will stop as soon as the unit unloads.

The time is adjustable from 0 to 20 minutes.

The default setting for the Auto Timer is zero.

**Remote Halt**

Immediate or Timed Unload.

If Immediate is chosen, the compressor will stop just as if the stop button was pushed. The unit will unload, blowdown and stop when the Stop Timer has reached 0. The Stop Timer has a default time of 0.

If Timed Unload is selected, the Blowdown timer and the Auto Timer must each time out before the compressor stops.

**Auto Restart**

This can be selected as either OFF or ON.

When ON is selected, the compressor will automatically RESTART when power is restored after a power failure.

When OFF is selected, the compressor will NOT RESTART when power is restored. The compressor must be manually restarted.
### MAINTENANCE ADJUST

The following counters can be reset after service has been performed.

- Next Oil Filter
- Next Oil Change
- Next Oil Separator
- Next Air Filter
- Next Control Box Filter
- Next Motor Lube

### SEQUENCE ADJUST

The following adjustments affect sequencing.

- No. of Sequenced Units
- Unit No.
- Sequence Group
- Transfer Interval
- Lag Start Delay Timer
- Set Baud Rate
- IP Address
- Subnet Mask
- Gateway Address
- Transfer Load Decrement
- Transfer Load Increment
- Stable Pressure Time

### UNIT SETUP ADJUST

(Password required) Allows the following setup values to be modified from factory default settings.

- Unit Password
- Oil Filter Change Interval
- Oil Change Interval
- Separator Change Interval
- Air Filter Change Interval
- Control Box Filter Change Interval
- Motor Lube Interval
- High Plant Pressure Limit
- Over Temperature Limit
- Temperature Alarm Limit
- Plant Temperature Limit
- Plant Temperature Alarm
- Dryer Temperature Limit
- Dryer Temperature Alarm
- Select Fan Type
- Motor Jog
- Drain Interval (rev)
### General-Service Packaged Air Compressors and Receivers

<table>
<thead>
<tr>
<th>Configuration Adjust</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compressor Model</td>
<td>(Password required) Allows the following configuration values to be modified from factory default settings.</td>
</tr>
<tr>
<td>Remove Reservoir Pressure</td>
<td></td>
</tr>
<tr>
<td>Remove Separator Pressure</td>
<td></td>
</tr>
<tr>
<td>Remove Plant Pressure</td>
<td></td>
</tr>
<tr>
<td>Distributor Info 1 (Contact Name)</td>
<td></td>
</tr>
<tr>
<td>Distributor Info 2 (Contact Number)</td>
<td></td>
</tr>
<tr>
<td>Energy Cost</td>
<td></td>
</tr>
<tr>
<td>System Voltage</td>
<td></td>
</tr>
<tr>
<td>Elevation</td>
<td></td>
</tr>
</tbody>
</table>

### Advisory Messages

<table>
<thead>
<tr>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drain Interval (hrs)</td>
</tr>
<tr>
<td>Limit Capacity</td>
</tr>
<tr>
<td>Motor Heater</td>
</tr>
<tr>
<td>Minimum Target Pressure</td>
</tr>
<tr>
<td>Oil Type</td>
</tr>
</tbody>
</table>

### Advisory Messages

<table>
<thead>
<tr>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change Separator Differential pressure &gt; 8 PSIG.</td>
</tr>
<tr>
<td>Change Air Filter Vacuum switch on package inlet has tripped.</td>
</tr>
<tr>
<td>Change Air Filter Maintenance timer for air filter change has expired.</td>
</tr>
<tr>
<td>Change Oil Filter Maintenance timer for oil filter change has expired.</td>
</tr>
<tr>
<td>Change Oil Maintenance timer for oil change has expired.</td>
</tr>
<tr>
<td>Low Amb Temp A Package discharge temperature &lt; 40°F (4°C).</td>
</tr>
<tr>
<td>Low Amb Temp B Separator temperature &lt; 40°F (4°C).</td>
</tr>
<tr>
<td>High Inlet Temp Temperature at package inlet &gt; 113°F (45°C).</td>
</tr>
<tr>
<td>Change Separator Maintenance timer for separator element change has expired.</td>
</tr>
<tr>
<td>High Disch Temp Temperature at airend discharge &gt; 230°F (110°C).</td>
</tr>
<tr>
<td>Optional Alarm Digital input programmed for Optional Alarm has tripped.</td>
</tr>
<tr>
<td>Low Voltage Digital input programmed for Low Voltage has tripped.</td>
</tr>
<tr>
<td>Motor Overtemp Digital input programmed for Motor Over Temperature has tripped.</td>
</tr>
<tr>
<td>Water Pressure Digital input programmed for Water Pressure has tripped.</td>
</tr>
<tr>
<td>High Vibration Digital input programmed for High Vibration has tripped.</td>
</tr>
<tr>
<td>High Dryer Temp Temperature at dryer &gt; 200°F (93°C).</td>
</tr>
<tr>
<td>Change Motor Lube Motor lubrication interval timer has expired.</td>
</tr>
<tr>
<td>Plant Pressure Compressor is unable to maintain target pressure setting.</td>
</tr>
<tr>
<td>V1 Max Sink Temp Main drive heatsink temperature &gt; 170°F (76.7°C).</td>
</tr>
<tr>
<td>Chng Ctrl Box Filter Control box filter change interval timer has expired.</td>
</tr>
</tbody>
</table>

### Alarm Messages (Shut downs)

<table>
<thead>
<tr>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fan Fault Cooler or vent fan over temp fault.</td>
</tr>
<tr>
<td>Drive 1 Fault Main motor VFD has shut down.</td>
</tr>
<tr>
<td>Emergency Stop Compressor stopped using Emergency Stop button.</td>
</tr>
<tr>
<td>Open Xducer XD5 Connection to pressure transducer XD5 is open.</td>
</tr>
<tr>
<td>High Plant Pres Pressure at package discharge &gt; 190 psig (13 bar).</td>
</tr>
<tr>
<td>Shorted Xducer XD5 Connection to pressure transducer XD5 is shorted.</td>
</tr>
<tr>
<td>Open Xducer XD3 Connection to pressure transducer XD3 is open.</td>
</tr>
<tr>
<td>High Resvr Pres Pressure at airend discharge &gt; 190 psig (13 bar).</td>
</tr>
<tr>
<td>Shorted Xducer XD3 Connection to pressure transducer XD3 is shorted.</td>
</tr>
</tbody>
</table>
### General Service Packaged Air Compressors and Receivers

<table>
<thead>
<tr>
<th>Condition</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open Therm T3</td>
<td>Connection to thermistor T3 is open.</td>
</tr>
<tr>
<td>High Disch Temp</td>
<td>Temperature at air end discharge &gt; 240°F (115°C).</td>
</tr>
<tr>
<td>Shorted Therm T3</td>
<td>Connection to thermistor T3 is shorted.</td>
</tr>
<tr>
<td>Open Therm T1</td>
<td>Connection to thermistor T1 is open</td>
</tr>
<tr>
<td>High Inlet Temp</td>
<td>Temperature at package inlet &gt; 113°F (45°C).</td>
</tr>
<tr>
<td>Shorted Therm T1</td>
<td>Connection to thermistor T1 is shorted.</td>
</tr>
<tr>
<td>Fan Starter</td>
<td>Fan Aux input does not match Cooler Start digital output.</td>
</tr>
<tr>
<td>Drive 1 Starter</td>
<td>Main motor VFD start failure.</td>
</tr>
<tr>
<td>Power Failure</td>
<td>Loss of power to compressor package.</td>
</tr>
<tr>
<td>XB1 Comm Error</td>
<td>Controller internal communications failure.</td>
</tr>
<tr>
<td>Drive 1 Comm Error</td>
<td>Communications failure between controller and main motor VFD.</td>
</tr>
<tr>
<td>Optional Shutdown</td>
<td>Digital input programmed for Optional Shutdown has tripped.</td>
</tr>
<tr>
<td>Low Voltage</td>
<td>Digital input programmed for Low Voltage has tripped.</td>
</tr>
<tr>
<td>Phase Sequence</td>
<td>Digital input programmed for Phase Sequence has tripped.</td>
</tr>
<tr>
<td>Motor Overtemp</td>
<td>Digital input programmed for Motor Over Temperature has tripped.</td>
</tr>
<tr>
<td>Water Pressure</td>
<td>Digital input programmed for Water Pressure has tripped.</td>
</tr>
<tr>
<td>High Vibration</td>
<td>Digital input programmed for High Vibration has tripped.</td>
</tr>
<tr>
<td>Zero Xducer XD5</td>
<td>Pressure transducer XD5 not calibrated.</td>
</tr>
<tr>
<td>Zero Xducer XD3</td>
<td>Pressure transducer XD3 not calibrated.</td>
</tr>
<tr>
<td>Controller Error</td>
<td>Controller internal failure.</td>
</tr>
<tr>
<td>EEPROM Restored</td>
<td>Main parameter set in nonvolatile memory restored with backup set.</td>
</tr>
<tr>
<td>Invalid Model</td>
<td>Valid compressor model not selected during factory setup or controller replacement.</td>
</tr>
<tr>
<td>DC Power Low</td>
<td>24 VDC input to controller &lt; 20 VDC.</td>
</tr>
<tr>
<td>High Dryer Temp</td>
<td>Temperature at dryer &gt; 220°F (104°C).</td>
</tr>
<tr>
<td>Open Therm T6</td>
<td>Connection to thermistor T6 is open.</td>
</tr>
<tr>
<td>Shorted Therm T6</td>
<td>Connection to thermistor T6 is shorted.</td>
</tr>
<tr>
<td>CM Table Invalid</td>
<td>Model Table in memory has been corrupted.</td>
</tr>
<tr>
<td>Actuator Comm Error</td>
<td>Communications failure between controller and mixing valve.</td>
</tr>
</tbody>
</table>

B. This comprehensive list of controls and information ensures that the compressor is operated safely and efficiently.

### Warranty & Startup

#### 2.15 Warranty & Startup

**A. Standard Warranty**

1. The compressor package is warranted to be free of defects in material and workmanship for a minimum period of 18 months from the date of shipment or 12 months from the date of start-up; whichever occurs first. The compressor air end assembly is warranted to be free of defects in material and workmanship for a minimum period of 27 months from the date of shipment or 24 months from the date of start-up; whichever occurs first.

**B. Extended Warranty**

1. In addition to the standard warranty, the air end assembly is warranted for 123 months from the date of shipment or 120 months from the date of start-up. All major package components (i.e.
package controller, both drive motor and cooling fan motor, and air/oil reservoir.) are warranted to be free of defects in material and workmanship for a minimum period of 63 months from the date of shipment or 60 months from the date of start-up; whichever occurs first.

C. Program requirements

1. Registration Form (BP-40) must be completed and returned to manufacturer within 30 days of the compressor package start-up date. Use of genuine OEM parts and lubricant (or warranty kits), as specified in the service manual, must be purchased from an authorized distributor. Participation in oil analysis sampling program and use of approved lubricants is required.

D. Start-Up Service

1. Start-up service is coordinated by factory trained technicians to ensure equipment is running properly and adjusted to factory specifications. Maintenance instructions will be discussed with the end user to ensure they understand routine maintenance procedures. The maintenance training shall be conducted at the time of equipment start-up.

2.16 ACCEPTANCE TEST STANDARD

A. Before shipment, each compressor is tested under CAGI/PNEUROP standard PN2CPTC2 (US) or ISO1217 Appendix C (Europe).

PART 3 - EXECUTION

3.1 EQUIPMENT INSTALLATION

A. Equipment Mounting:

1. Install air compressors on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 03 30 00 "Cast-in-Place Concrete."
2. Comply with requirements for vibration isolation and seismic control devices specified in Section 22 05 48 "Vibration and Seismic Controls for Plumbing Piping and Equipment"
3. Comply with requirements for vibration isolation devices specified in Section 22 05 48.13 "Vibration Controls for Plumbing Piping and Equipment."

B. Install compressed-air equipment anchored to substrate.

C. Arrange equipment so controls and devices are accessible for servicing.

D. Maintain manufacturer's recommended clearances for service and maintenance.

E. Install the following devices on compressed-air equipment:

1. Thermometer, Pressure Gage, and Safety Valve: Install on each compressed-air receiver.
2. Pressure Regulators: Install downstream from air compressors.
3. Automatic Drain Valves: Install on aftercoolers, receivers, and dryers. Discharge condensate over nearest floor drain.
3.2 CONNECTIONS

A. Comply with requirements for piping specified in Section 22 15 13 "General-Service Compressed-Air Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to machine, allow space for service and maintenance.

3.3 IDENTIFICATION

A. Identify general-service air compressors and components. Comply with requirements for identification specified in Section 22 05 53 "Identification for Plumbing Piping and Equipment."

3.4 DEMONSTRATION

A. [Engage a factory-authorized service representative to train] [Train] Owner's maintenance personnel to adjust, operate, and maintain air compressors[ and aftercoolers][ and air dryers] [, aftercoolers, and air dryers].

3.5 TRAINING

A. Training will be performed for each system installed. Training is to be two separate identical sessions, held on separate weeks. A training Agenda will be developed by the Commissioning Authority. Contractor is responsible to have a competent party perform training, preferably the site foreman in conjunction with manufacturer's representatives.

END OF SECTION 22 15 19
PART 1 GENERAL

1.1 INTENT OF LABORATORY PLUMBING SPECIFICATION SECTION

A. The intent of this section is to provide information which is supplemental to all other divisions and sections of the specifications, and in particular to Division 22 Plumbing work, which shall be specifically related to the plumbing construction within the areas defined under the Laboratory scope of work. It is not intended to make any deletions, either explicitly or implicitly, to any of the other division or section requirements, and these sections do not relieve the Contractor from complying in all respects with other divisions and sections of the specifications. The other divisions and sections shall be considered to be an integral part of the Laboratory Plumbing work and shall be modified only as defined herein. Any questions the Contractor has with respect to the intent of the Laboratory Plumbing work sections should be addressed during the bidding period. Clarifications will be provided upon written request.

1.2 WORK INCLUDED

A. Provide complete plumbing systems from point of rough-in and final connections as described in these specifications and as shown on the Contract Drawings. Plumbing installations shall include all piping, valves, connectors and miscellaneous equipment to provide complete operable systems, in accordance with the best practices of the trade.

B. Except as modified by this section, all products, equipment, installation procedures, and general conditions contained within Division 22 Plumbing sections of these specifications applies to work specified in this section.

C. Work under this section includes, but is not limited to, installation of branch supply piping from main piping systems to points of termination within the laboratories, as well as laboratory waste and vent piping from between floor and ceiling.

D. Work NOT included under this section is as follows:

1. Laboratory waste piping below point of connection at the floor slab
2. Laboratory vent piping beyond point of connection above ceiling
3. Building distribution main piping systems
4. Fire sprinkler systems
5. Steam and condensate piping systems

Refer to Divisions 21, 22, and 23 for above work.

1.3 RELATED WORK DESCRIBED ELSEWHERE

A. General and Supplementary Conditions and Division 1

B. Section 11 53 10 – Laboratory Casework and Other Furnishings

C. Section 11 53 13 – Fume Hoods and Other Air Containment Units
D. Section 11 53 43 – Laboratory Service Fittings and Fixtures
E. Division 22 – Plumbing
F. Division 23 – Heating Ventilating and Air Conditioning
G. Division 26 – Electrical

1.4 REFERENCES
A. In addition to complying with all applicable trade and building codes and regulations, comply with applicable portions of the National Sanitation Foundation (NSF) standards.

1.5 DEFINITIONS
A. Above Finished Floor: Inside building within a zone usually considered at ± 6" above floor finish.
B. Above Finished Ceiling: Inside building within a zone usually considered at ± 6" above ceiling finish.
C. Below Slab: Located in ceiling space of floor below, buried in ground, or embedded in concrete slab on ground.
D. Concealed: Inside building, above grade and located within walls, furred spaces, service cores, pipe drop enclosures, above suspended ceilings, etc. In general any item not visible or directly accessible.
E. Connect: Complete hookup of item with required services, including all adapters and fittings.
F. Exposed: Either visible or subject to mechanical or weather damage, indoors or outdoors, including areas such as mechanical and storage rooms. In general any item that is directly accessible without removing panels, walls, ceiling or other parts of structure commonly used as reference to surface mounted piping, etc.
G. Point of Connection: Point within a piped system at which responsibility of this section either begins or ends. i.e. laboratory waste begins at fixture outlet and ends at Point of Connection (P.O.C.) ± 6" above floor finish. From there to be continued on Plumbing Drawings, and remainder of Division 22 specifications.

1.6 CLOSING IN UNINSPECTED WORK
A. Do not cover or enclose work prior to testing, inspection, and approval. All work covered or enclosed prior to approval and acceptance shall be re-opened. All finishes shall be restored.

1.7 SUBMITTALS
A. Submit as specified herein and under provisions of Division 1 “Submittal Requirements”.
B. Submittal shall be complete with all product data specified herein and organized by specification reference section into a single electronic file. All submitted product data shall be referenced to the applicable paragraph number contained within this specification section.
C. Manufacturer’s Data: Submit complete materials list, including catalog data, of all materials, equipment, and products for work in this section.

D. Shop Drawings: Submit coordinated shop drawings depicting the work specified herein for actual fabrication and installation. Work shall be coordinated with other trades and building structural and architectural elements. Shop drawings shall include plans, elevations, and sections as required depicting the intended installation and final product. Drawings shall be electronically prepared in AutoCAD or similar software and submitted in a complete package with minimum ¼ inch = 1 ft scale format and maximum sheet size of Architectural “E” (30” x 42”).

1.8 RECORD DRAWINGS

A. The Contractor shall maintain an up-to-date set of “red-line” prints, marked to indicate progress of the Project and all as-built conditions. Prints shall be updated on a daily basis, and shall be available for review at all times on the job site.

B. Record Drawings shall indicate locations of all equipment and pipe rerouting, as well as any changes in locations or positions of equipment.

C. Comply with Division 1 “Project Closeout” for Record Drawings requirements.

1.9 SUBSTITUTIONS

A. Approved Substitution/Approved Equal: In addition to the items required in Division 1, all substitution requests shall include item-by-item comparison of the proposed substitution to this project specification. A copy of the project specification shall be submitted, with each item and subsection of the project specification marked as “Comply” or “Not Comply.” In any cases where “Not Comply” is indicated, an explanation of the relative advantages of the proposed design shall be provided.

B. Substitution shall not affect dimensions shown on Drawings.

C. The Contractor shall pay for changes to the building design, including engineering design, detailing, utility and service requirements, and construction costs caused by the requested substitution.

D. Substitutions shall have no adverse effect on other trades, the construction schedule, or specified warranty requirements.

E. Maintenance and service parts shall be locally available for the proposed substitution.

PART 2 PRODUCTS

2.1 PIPING AND FITTINGS

A. Domestic Cold, Hot, and Tepid Water:
   
   1. Provide pipe and fittings as specified in Section 22 11 16.
   2. Flexible Connectors: Provide 150 psi WOG working pressure rating, single braid, and stainless steel hose with chrome plated brass threaded end connections. Manufacturers: US Hose Corp., Hyspan, or approved equal.
   3. Flexible Tubing: Provide ASTM B 88 Type L, soft, annealed, seamless copper tubing.

B. Compressed Air:
   1. Provide pipe and fittings as specified in Section 22 15 13.
   2. Threaded joints in distribution piping shall be limited to connections to pressure/vacuum indicators, alarm devices, and source equipment. All threads shall be tapered pipe threads complying with ANSI B1.20.1 and be made up with polytetrafluoroethylene (such as Teflon™) tape or other thread sealant recommended for oxygen service, with the sealant applied to the male threads only. Where threaded nipples are required these shall be I.P.S. brass.
   3. Flexible Connectors: Provide 150 psi WOG working pressure rating, single braid, stainless steel hose with brass threaded end connections. Connectors shall be cleaned to remove manufacturing residue oils and debris. Manufacturers: US Hose Corp., Hyspan, or approved equal.

C. Laboratory Waste and Vent:
   1. Provide pipe and fittings as specified in Section 22 66 00.
   2. Provide chrome-plated brass waste piping for tailpiece, P-trap, and trap arm at exposed-to-view locations for installations of emergency eyewash Laboratory fixtures and wall-hung hand wash sinks.

2.2 VALVES

A. Domestic Cold, Hot, and Tepid Water:
   1. Fixture Supply Stop Valves:
   2. Shutoff Valves:
      a. Provide ball valves as specified in Section 22 05 23.12.
   3. Check Valves:
      a. Provide Y-pattern check valves as specified in Section 22 11 19.
   4. Vacuum Breakers: Provide vacuum breakers on potable water services as accepted by local building Authority and as specified in Section 22 11 19.
   5. Back Flow Preventers: Provide reduced-pressure-principle backflow preventers on potable water services supplying laboratory equipment, as accepted by local building Authority, and as specified in Section 22 11 19.
   6. Pressure regulators: Provide adjustable water pressure regulators service fitting connection size and as specified in Section 22 11 19.

B. Compressed Air:
   1. Shutoff Valves:
      a. Provide as specified in Section 22 05 23.12.
   2. Pressure Regulators: Provide pressure regulator with pressure gauge, adjustable from 10 to 120 psi, at compressed air point of connection to laboratory. Manufacturers: Norgren Excelon 73, Watts R10, or approved equal.
2.3 PROTECTIVE PIPE COVER (AT EXPOSED P-TRAP ARMS)

A. Manufacturers: Products, which comply with this specification section as judged and approved by the Architect, may be provided by the following manufacturers. All products specified in this section shall be provided by a single manufacturer.

2. Approved equal

B. Basis of Design: Truebro LAV GUARD undersink protective pipe cover.

C. Description: Flexible, molded, antimicrobial, closed cell vinyl pipe cover and fittings for P-trap, angle valve, tailpiece, extension arm, supply tube, etc. components below sink.

D. Material Characteristics:

1. Wall thickness: 1/8 inch (3 mm)
2. Durometer: 60 – 70 Shore A
3. Finish: Smooth high gloss
4. Color: White
5. UV Protection: Will not fade or discolor
6. Flame Characteristics (ASTM D 635): 0 sec. (ATB), 0 mm (AEB)
7. Thermal conductivity (K value): 1.17 plus dead air space

E. Features:

1. Fasteners: Reusable snap clips
2. Protective wrap shall install without disassembling plumbing
3. Latching covers to access angle stops
4. Removable cleanout nut for servicing

2.4 INSULATION

A. Insulate laboratory piping as specified in Section 22 07 19 for the respective systems.

2.5 PIPING HANGERS, SUPPORTS AND GUIDE

A. Provide hangers and supports as specified in Section 22 05 29.

2.6 PIPING AND EQUIPMENT IDENTIFICATION

A. Provide identification for plumbing piping and equipment as specified in Section 22 05 53.

PART 3 EXECUTION

3.1 CONNECTION

A. Connect laboratory piping to P.O.C. valves shown on Plumbing drawings and to laboratory services. Provide threaded couplings at final connection to service fittings and valve stops.
B. Laboratory Waste and Vent:

1. Laboratory Waste: Connect laboratory fixture/outlet waste to P.O.C. of laboratory waste. Extend piping from tail piece connector with trap and trap arm,
2. Laboratory Vent: Connect fixture trap arm to P.O.C. of laboratory vent.

3.2 INSTALLATION

A. Domestic Cold, Hot, and Tepid Water:

1. Extend piping from P.O.C. to services as indicated on LP-series drawings. Provide threaded couplings at final connection to service fittings and valve stops.
2. Install approved pressure regulators on laboratory equipment connections when required by equipment manufacturer. Set delivery pressure within equipment manufactures’ specifications.
3. Install water hammer arrestors on water piping that serves quick closing or solenoid operated valves for equipment or laboratory services. Water hammer arrestors shall be installed upstream of these valves in accordance with manufacturer’s recommendations.
4. Fixture Connection: Install supply stop valve for each service to fixture as indicated on LP-series drawings. Install flexible connector or flexible tubing from valve to fixture supply water connections.
5. Extend tepid domestic water piping from P.O.C. to drench hoses and safety shower/eyewash units as indicated on LP-series drawings.
6. Refer to corresponding sections of Division 22 for system cleaning and disinfecting requirements.

B. Compressed Air:

1. Extend piping from P.O.C. to services as indicated on LP-series drawings.
2. Fixture Connection: Install flexible connector from piping to fixture connection as indicated on LP-series drawings.
3. Copper Tubing Brazing Procedures:
   a. Brazed joints shall be made using a brazing alloy that exhibits a melting temperature in excess of 538°C (1000°F). Copper-to-copper joints shall be brazed using a copper–phosphorus–silver brazing filler metal (BCuP series) without flux. Flux shall only be used when brazing dissimilar metals such as copper and bronze or brass, using a silver (BAg series) brazing filler metal. Brazing alloy comply with ANSI/AWS A.5.8 Specification for Brazing Filler Metal. Residual flux on interior surfaces of tubing and fittings must be completed removed with cleaning processes.
   b. While being brazed, all piping joints shall be continuously purged with oil-free, dry Nitrogen to prevent the formation of copper oxide on the inside surfaces of the joint. The purge shall be maintained until the joint is cool to the touch.

C. Laboratory Waste and Vent:

1. Install horizontal pipe with uniform slope of 1/4-inch per foot (minimum).
2. Use reduction fittings, not bushings, to connect pipes of different diameters.
3. Change direction by appropriate use of 45-degree wyes, long sweep quarter-bends, and sixth-, eighth-, and sixteenth-bends.
4. All fixture traps shall be of the "P" type with mechanical joints for removal.
5. No vent shall intersect another vent at a point less than six inches above the extreme overflow level of the highest fixture served unless said fixtures are located back to back, in which a sanitary "TEE" may be used.
6. Vents shall be taken off the top half of horizontal runs and shall be graded so as will quickly drain any water or condensate.
3.3 TESTS

A. Contractor shall thoroughly test all Work prior to operation in the presence of Owner's Representative. Any Work showing faults under test shall be replaced. Contractor shall maintain an accurate written record of all tests and test results, and shall submit three copies of all final tests to the Owner's Representative.

B. Refer to Division 22 specifications for system test requirements. If not specified elsewhere, minimum requirements shall be as follows:

1. Domestic Cold, Hot, and Tepid Water: Test under a cold water hydrostatic pressure of 150 psig for a period of four (4) hours and carefully check for leaks. Repair all leaks and re-test system until proven watertight with no loss of pressure or leakage allowed.

2. Compressed Air: Test and prove airtight under an air pressure of 150 psig for a period of four (4) hours and bubble test all joints with a soap solution. Repair all leaks and re-test system until proven airtight with no loss of pressure or leakage allowed.

END OF SECTION 22 20 00
SECTION 22 35 00 - DOMESTIC-WATER HEAT EXCHANGERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Circulating, storage, domestic-water heat exchangers.
   2. Domestic-water, heat-exchanger accessories.

1.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Domestic-water heat exchangers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
   1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

1.3 ACTION SUBMITTALS

A. Product Data: For each type and size of domestic-water heat exchanger indicated.

B. Shop Drawings:
   1. Wiring Diagrams: For power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For domestic-water heat exchangers, accessories, and components, from manufacturer.

B. Product certificates.

C. Domestic-Water, Heat-Exchanger Labeling: Certified and labeled by testing agency acceptable to authorities having jurisdiction.

D. Source quality-control reports.

E. Field quality-control reports.

F. Warranty: Sample of special warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.
1.6 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1.

C. ASME Compliance: Where ASME-code construction is indicated, fabricate and label heat-exchanger storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

D. NSF Compliance: Fabricate and label equipment components that will be in contact with potable water to comply with NSF 61, “Drinking Water System Components - Health Effects.”

1.7 WARRANTY

A. Special Warranty: Manufacturer’s standard form in which manufacturer agrees to repair or replace components of domestic-water heat exchangers that fail in materials or workmanship within specified warranty period.

1. Warranty Periods: From date of Substantial Completion.
   a. Circulating, Storage, Domestic-Water Heat Exchangers:
      1) Storage Tank: Five years.
      2) Plate Exchanger: Five years.
      3) Controls and Other Components: Three years.

PART 2 - PRODUCTS

2.1 CIRCULATING, DOMESTIC-WATER HEAT EXCHANGERS

A. Circulating, Storage, Domestic-Water Heat Exchangers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Cemline Corporation.
   b. Patterson-Kelley.
   c. PVI Industries, LLC.
   d. RECO USA.
   e. Smith, A. O. Corporation.

2. Description: Packaged, large-capacity, hot-water storage tank with brazed plate heat-exchanger; circulator; controls; and specialties for heating domestic water with heating hot water in coil.

3. Flow Pattern: Standard-flow arrangement, with water from bottom of storage tank circulated across heat-exchanger coil and returned to tank. Include hot-water outlet located at top of tank and temperature sensor in tank.

4. Flow Pattern: Reverse-flow arrangement, with water from storage tank drawn across heat-exchanger coil and returned to bottom of tank. Include hot-water outlet and temperature sensor located in or at coil shell.
   b. Manhole: 11 by 15 inches in sidewall of vertical storage-tank shell.
   c. Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing and labeling.
      1) NPS 2 and Smaller: Threaded ends according to ASME B1.20.1.
      2) NPS 2-1/2 and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges and according to ASME B16.24 for copper and copper-alloy flanges.
   d. Lining: Cement complying with NSF 61 barrier materials for potable-water tank linings, including extending lining into and through tank fittings and outlets.
   e. Insulation: Complying with ASHRAE/IESNA 90.1, unless otherwise indicated, and suitable for operating temperature. Surround entire storage tank and nozzle except connections and controls.


7. Temperature Control: Adjustable temperature aquastat, mounted in storage-tank shell head unless otherwise indicated.

8. Safety Control: Automatic, high-temperature-limit cutoff device or system. Include automatic low-water cutoff device or system.

9. Relief Valves: ASME rated and stamped for combination temperature-and-pressure relief valves. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than working-pressure rating of heat exchanger. Select one relief valve with sensing element that extends into storage tank.


11. Circulating Pump: UL 778, all-bronze, centrifugal, overhung-impeller, separately coupled in-line pump as defined in HI 1.1-1.2 and HI 1.3. Include mechanical seals, 125-psig minimum working-pressure rating, and 225 deg F continuous-water-temperature rating.
   a. Pump Control: Sensor for operating pump and control valve.


B. Capacity and Characteristics: See Schedule on Drawings

   2. Recovery: 218 gph at 80 deg F temperature rise.
   3. Hot-Water Temperature Setting: 130 deg F.
   4. Heating Hot-Water Supply:
      a. Inlet Temperature: 135 deg F
      b. Outlet Temperature: 110 deg F

2.2 DOMESTIC-WATER, HEAT-EXCHANGER ACCESSORIES

A. Domestic-Water Compression Tanks:
B. Heat-Trap Fittings: ASHRAE 90.2.

C. Combination Temperature-and-Pressure Relief Valves: ASME rated and stamped. Include relieving capacity at least as great as heat input, and include pressure setting less than heat-exchanger working-pressure rating. Select relief valves with sensing element that extends into storage tank.

D. Pressure Relief Valves: ASME rated and stamped. Include pressure setting less than heat-exchanger working-pressure rating.

2.3 SOURCE QUALITY CONTROL

A. Factory Tests: Test and inspect domestic-water heat exchangers specified to be ASME-code construction, according to ASME Boiler and Pressure Vessel Code.

B. Hydrostatically test domestic-water heat exchangers to minimum of one and one-half times pressure rating before shipment.

C. Domestic-water heat exchangers will be considered defective if they do not pass tests and inspections. Comply with requirements in Section 01 40 00 "Quality Requirements" for retesting and reinspecting requirements and Section 01 73 00 "Execution" for requirements for correcting the Work.

D. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 DOMESTIC-WATER, HEAT-EXCHANGER INSTALLATION

Comply with requirements for concrete bases specified in Section 03 30 00 "Cast-in-Place Concrete."

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.
5. Anchor heat exchangers to substrate.

B. Install domestic-water heat exchangers level and plumb, according to layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.

1. Install shutoff valves on domestic-water-supply piping to heat exchangers and on domestic-hot-water outlet piping. Comply with requirements for shutoff valves specified in Section 22 05 23.12 "Ball Valves for Plumbing Piping, and Section 22 05 23.15 "Gate Valves for Plumbing Piping."

C. Install domestic-water heat exchangers with seismic-restraint devices. Comply with requirements for seismic-restraint devices specified in Section 22 05 48 "Vibration and Seismic Controls for Plumbing Piping and Equipment."
D. Install temperature and pressure relief valves in top portion of storage-tank shells of domestic-water heat exchangers with domestic-water storage. Use relief valves with sensing elements that extend into shells. Extend relief-valve outlet, with drain piping same as domestic-water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.

E. Install combination temperature-and-pressure relief valves in water piping for domestic-water heat exchangers without storage. Extend relief-valve outlet, with drain piping same as domestic-water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.

F. Install heat-exchanger drain piping as indirect waste to spill by positive air gap into open drains or over floor drains. Install hose-end drain valves at low points in water piping for domestic-water heat exchangers that do not have tank drains. Comply with requirements for hose-end drain valves specified in Section 22 11 19 "Domestic Water Piping Specialties."

G. Install thermometer on each domestic-water, heat-exchanger, inlet and outlet piping, and install thermometer on each domestic-water, heat-exchanger, heating-fluid inlet and outlet piping. Comply with requirements for thermometers specified in Section 22 05 19 "Meters and Gages for Plumbing Piping."

H. Install pressure gages on domestic-water, heat-exchanger, heating-fluid piping. Comply with requirements for pressure gages specified in Section 22 05 19 "Meters and Gages for Plumbing Piping."

I. Fill domestic-water heat exchangers with water.

J. Charge domestic-water compression tanks with air.

3.2 CONNECTIONS

A. Comply with requirements for piping specified in Section 22 11 16 "Domestic Water Piping."

B. Comply with requirements for heating hot-water piping specified in Section 23 21 13 "Hydronic Piping" and Section 23 21 16 "Hydronic Piping Specialties." Section 15179 "Hydronic Piping Specialties."

C. Comply with requirements for steam and condensate piping specified in Section 23 22 13 "Steam and Condensate Heating Piping" and Section 23 22 16 "Steam and Condensate Piping Specialties."

D. Drawings indicate general arrangement of piping, fittings, and specialties.

E. Where installing piping adjacent to domestic-water heat exchangers, allow space for service and maintenance of heat exchangers. Arrange piping for easy removal of domestic-water heat exchangers.

3.3 IDENTIFICATION

A. Identify system components. Comply with requirements for identification specified in Section 22 05 53 "Identification for Plumbing Piping and Equipment."

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections.
1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

3. Operational Test: After electrical circuitry has been energized, start units to confirm proper operation.

4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Domestic-water heat exchangers will be considered defective if they do not pass tests and inspections. Comply with requirements in Section 01 40 00 "Quality Requirements" for retesting and reinspecting requirements and Section 01 73 00 "Execution" for requirements for correcting the Work.

C. Prepare test and inspection reports.

3.5 DEMONSTRATION

A. Train Owner’s maintenance personnel to adjust, operate, and maintain circulating domestic-water heat exchangers.

3.6 TRAINING

A. Training will be performed for each system installed. Training is to be two separate identical sessions, held on separate weeks. A training Agenda will be developed by the Commissioning Authority. Contractor is responsible to have a competent party perform training, preferably the site foreman in conjunction with manufacturer’s representatives.

END OF SECTION 22 35 00
SECTION 22 35 13 - MODULAR SCROLL CHILLER/HEAT PUMP FOR DOMESTIC WATER HEATING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract.

1.2 SUMMARY

A. This Section includes water-cooled modular water chillers, for domestic hot water heating.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. LEED Submittals:
   1. Product Data for Credit EA 4: Documentation indicating that equipment and refrigerants comply.
   2. Product Data for Prerequisite IEQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."

C. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   1. Include diagrams for power, signal, and control wiring.

1.4 SUBMITTALS

A. The chiller manufacturer must submit the following criteria by which the chiller bid will be evaluated.

B. Submit the following:
   1. Manufacturer’s warranty details specified in Article 1.5 below.
   2. Product Data: Include refrigerant, rated capacities, operating characteristics, furnished specialties, and accessories. Specifically, include:
      a. Heating capacity in BTU/hr, COP and NPLV
      b. Minimum evaporator flow rate
   3. Shop Drawings: Complete set of manufacturer's certified prints of water chiller assemblies, control panels, sections and elevations, and unit isolation. Include the following:
      a. Assembled unit dimensions.
      b. Evaporator and condenser heat exchanger construction
      c. Compressor data
      d. Required clearances for maintenance and operation.
      e. Size and location of piping and wiring connections.
      f. Wiring Diagrams: Power, signal, and control wiring.
Control panel product data and BAS interface information

4. Warranty Certificate

C. Submit the following after award of contract:

1. Certificates: For certification required in “Quality Assurance” Article
2. Startup service reports.
3. Operation and Maintenance Data: For each equipment item to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Products shall be Designed, Tested, Rated and Certified in accordance with, and installed in compliance with applicable sections of the following Standards and Codes:

2. ASHRAE 90.1– Energy Efficiency compliance.
4. ASME Boiler & Pressure Vessel Code, Section VIII, Division 1
5. ASHRAE 34 – Number Designation and Safety Classification of Refrigerants
6. ARI Standard 550/590 – Positive Displacement Compressors and Water Cooled Rotary Screw Water-Chilling Packages
7. Conform to UL code 1995 for construction of chillers and provide UL/cUL listing label for electrical panel construction.
8. Manufactured in facility registered to ISO 9001
9. OSHA - Occupational Safety and Health Act

B. Factory Test: Chiller shall be pressure-tested, evacuated and fully charged.

1.6 WARRANTY

A. Provide Manufacturer’s 1-year, “Parts-Only” Warranty. Refer to warranty details provided by the manufacturer.

B. Optional 5-year extended parts-only warranty for scroll compressors only (5 years total).

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. ClimaCool Corp. – Division of LSB Industries -- Model UCH HP

2.2 MANUFACTURED UNIT

A. Description: Factory-assembled and -wired water cooled heat pump. Unit consists of two or more compressors, an evaporator, a water cooled condenser, safety controls, and operational controls.
B. All modules’ electrical panels shall be constructed in accordance with UL and bear the UL Listing mark. Additionally, the heat exchangers shall bear the UL Stamp.

C. All modules shall be shipped completely wired and fully charged with refrigerant R-410a and oil, ready for installation. All modules shall be factory run tested at simulated full load design conditions prior to shipment.

D. The assembled chiller shall be completely capable of being serviced and repaired in place without the need for removal of a module. If modules need to be removed for servicing, the unit manufacturer shall provide a five year labor warranty with chiller.

E. Each module shall contain two hermetically sealed scroll compressors and be resiliently mounted to the module with rubber-in-shear isolation. Suction gas cooled compressor motor shall have a utilization range of ±10% from nameplate voltage and shall be equipped with internal thermostats for direct protection against overheating and external over current and single phasing protection. Each system also shall include high discharge pressure and low suction pressure cutouts.

F. Each module shall be complete with field installed sound attenuation panels. Panels shall enclose the complete module so all heat exchangers and compressors are not exposed.

2.3 REFRIGERANT

A. Material: R-410a -- provide full operating charge of refrigerant and oil. No other refrigerants are acceptable.

B. Refrigerant Circuit: Provide refrigerant charging port.

2.4 WATER-COOLED PACKAGED CHILLER/HEAT PUMP

A. System Description: Chiller shall incorporate scroll compressors and consist of multiple refrigerant circuits. Each module contains a high efficiency, dual cycled, 316 stainless steel brazed plate evaporator and condenser. Each refrigerant circuit contains a scroll compressor, thermostatic expansion valve, reversing valve, sight glass, filter drier, operating and safety controls. Each circuit is truly independent from other circuits with regard to both refrigeration and electrical redundancy. Evaporator, condenser, condenser water piping, chilled water piping, chilled water heaters, condenser water headers and all low temperature refrigerant tubing shall be wrapped with closed cell insulation to prevent condensation. The multi-circuited heat pump system shall be capable of producing chilled or hot water even in the event of a failure of one or more refrigerant circuits. All operating components for each module, including compressors, heat exchangers, piping, and controls shall be securely fastened to a unitized heavy gauge steel frame having an electro-statically applied powder, oven baked enamel finish. Compressor motor contactors, control transformers, (one for each compressor circuit), transformer primary and secondary fuses are located in the control panel. Each chiller module has two (2) steps of control (100%, 50% and off) by cycling off the compressors. All electrical controls, contactors, and relays, for each module shall be mounted within that module and be of the low voltage type.

B. Evaporators and condensers: Each evaporator and condenser shall be dual cycled, brazed plate heat exchangers constructed of 316 stainless steel; designed, tested, and UL stamped in accordance with ASME Section VIII pressure vessel code for 650 psig working refrigerant pressure on the evaporator and 650 psig working pressure on the condenser. Both the condenser and evaporator heat exchanger shall have a working pressure for the water circuits at least 285 psig. Both evaporator and condenser brazed plate heat exchangers shall have a waterside flush connection with ball valve on each module to
permit backflushing or cleaning of heat exchangers without removing chiller headers or other in place components. Manufactures providing a chiller where components need to be removed in order to backflush or clean the brazed plate heat exchanger shall provide a 10 year service contract to remove necessary components to clean the heat exchangers.

C. Compressor: Unit shall contain multiple hermetic scroll compressors independently circuited and with internal isolation mounted with rubber-in-shear isolators. Each compressor system also includes high discharge pressure and low suction pressure manual reset safety cut-outs. The compressors are direct-drive, hermetic, 3600 rpm (@ 60 Hz) fixed compression, scroll compressors. Each compressor has integral centrifugal oil pump, oil level sight-glass, oil charging valve, and an internal check valve on the scroll discharge port. Motor is suction gas-cooled, hermetically sealed, two-pole, squirrel cage induction type.

D. Master Controller System

1. Multiple Module Chillers
   a. Each chiller shall be equipped with a dedicated standalone direct digital control (DDC) system including a master controller and display which shall perform the numerous functions discussed in this section. All chiller operations and computer features shall be accessed through a LCD display. BAS interface to be provided by BACnet communication.
   b. A RS232 port shall be provided for use of an optional remote MS-DOS based PC monitoring and control software via hardwire or telephone modem.
   c. Each module control panel shall communicate with the master controller via low voltage cable. The module control panel shall monitor and control each refrigeration system in response to commands by the master computer. The master controller shall have a terminal strip to accept field wired low voltage system interlock such as flow switches, auxiliary contacts, remote start/stop, common alarm output, etc. The master controller shall be provided by the unit manufacturer and field mounted in the equipment room by others.

2. Safeguarding Operation of Refrigeration System
   a. Each module is equipped to control all alarm and fault conditions protecting the compressor and feedback input conditions and output conditions to the master controller for it to monitor individual chiller module status. The master controller shall continually monitor all of the following areas for each individual module’s refrigeration system through digital switching:
      1) Discharge pressure cutout.
      2) Suction pressure cutout.
      3) Solid state compressor motor protection.
      4) Evaporator leaving chilled water temperature (for module freeze protection).
   b. The master controller shall additionally monitor the following areas:
      1) Evaporator leaving chilled water temperature (for chiller capacity control).
      2) Evaporator entering chilled water temperature.
      3) Phase loss (each phase).
      4) Phase imbalance and phase reversal.
      5) Over-/under voltage.
      6) Evaporator flow status.
      7) Condenser flow status.
      8) Condenser entering water temperature.
      9) Condenser leaving water temperature.
c. A potentially unsafe (out of tolerance) condition from any of these controls or sensors shall cause a "fault" shutdown of that compressor with an automatic transfer of load requirements to another available compressor. A running history of the complete fault occurrence conditions shall be automatically maintained (up to the last 20 occurrences) should it ever be required for troubleshooting.

d. Continuous individual monitoring of leaving chilled water temperature from each module’s refrigeration system shall provide protection against freeze-up in the event of unusual, unexpected operating conditions.

E. The master controller must lead/lag the dual Scroll compressors, balance the run time, prevent short cycling of compressors, and register the last 20 failure occurrences. Fault conditions must be alarmed so the compressor can be taken off line. Both alarm and failed conditions must be displayed on digital display on front of the master control panel. An alarm relay for remote indication of faults and failed conditions with a normally open and normally closed dry contact must be supplied. The “Master Controller” must be able to be controlled by and monitored by the central controller. The operating control of chilled water outlet temperature must be able to be reset remotely with a 4-20ma input signal. Staging of the all scroll compressors, lead/lag of the compressors, equalize runtime of compressors and preventing compressor short cycling will be done by the master controller. Compressor staging is accomplished through PID control logic, adjustable in response times and settings. The system shall provide for variable time between compressor sequencing and temperature sensing. Inputs/Outputs to the Master controller include:

1. Remote Start/Stop
2. (Optional) Condenser Pump Interlock
3. Chiller Failure Output (Note: Chiller is comprised of one or more modules- Each module will indicate its own individual failure at the chiller. The "Chiller Failure" indication is a remote signal sent remotely to indicate that the chiller has had sufficient modules fail that operation of the chiller will not be beneficial. This failure signal shall be capable of adjusting to provide a failure signal according to the percentage of capacity that has failed.)
4. Evaporator Flow Status (Provided by differential pressure switch as provided by manufacturer)
5. Condenser Flow Status (Provided by differential pressure switch as provided by manufacturer)
6. Note: There are four temperature sensors & thermal wells provided with the chiller for field installation and wiring into the chiller control panel by others. These sensors are for monitoring entering and leaving water temperatures of the evaporator and condenser water mains connected to the chiller bank.
7. BAS Interface – BACnet interface shall be provided for communication to Building Automation System

F. Power Connections: Each module shall have its own electrical power panel mounted to the unit frame. Each module will be independently powered by a field installed fused disconnect switch (or equivalent module circuit breaker) supplied by others, so that any one module can be shut down for repair without interrupting the remaining chiller modules’ operation. The power panel for each module shall contain:

1. Main input terminal block
2. Compressor motor contractors
3. Motor overload protection per compressor
4. Individual compressor motor fusing or breakers
5. Local manual “ON” / “OFF” compressor switch to allow service or repair to individual modules and compressors without interrupting service of the entire chiller.
6. Single point power connection to entire chiller bank is not acceptable due to need for power redundancy. The use of buss bars to power chillers is unacceptable without individual module disconnects.

G. Motorized Water Isolation/Regulating Valves for Evaporator and Condenser - Each chiller module shall include as standard factory-installed motorized isolation valves in the chilled water branch line to the
module's evaporator and a manual valve from the evaporator for heat exchanger isolation. Each chiller
module shall include as standard factory-installed motorized isolation valves in the condenser water
branch line to the module's condenser and a manual valve from the condenser for heat exchanger
isolation. Modulating valves shall have built in water regulation and control to maintain proper module
head pressure. Solenoid or on/off valves are not acceptable.

H. Condenser Water Strainer.

1. A strainer shall be installed on the condenser inlet of the chiller bank. Strainer shall be basket
type with minimum 60-mesh rating. 30 mesh rated strainers are not acceptable due to their larger
mesh size.
2. Condenser strainers are field installed.
3. Strainers shall be installed external to chiller for ease of service. Strainers supplied internal to
chiller supply header shall be unacceptable. If provided, manufacturer shall include a 10 year
labor maintenance contract for strainer servicing and cleaning.

I. Evaporator Water Strainer.

1. A strainer shall be installed on the evaporator inlet of the chiller bank. Strainer shall be ‘Y’ type
with minimum 60-mesh rating. 30 mesh rated strainers are not acceptable due to their larger
mesh size.
2. Evaporator strainers are field installed.
3. Strainers shall be installed external to chiller for ease of service. Strainers supplied internal to
chiller supply header shall be unacceptable. If provided, manufacturer shall include a 10 year
labor maintenance contract for strainer servicing and cleaning.

2.5 SAFETIES, CONTROLS AND OPERATION

A. Chiller safety controls system shall be provided with the unit (minimum) as follows:

1. Low evaporator refrigerant pressure.
2. Loss of flow through the evaporator
3. Loss of flow through the condenser.
4. High condenser refrigerant pressure
5. High compressor motor temperature-
6. Low leaving evaporator water temperature
7. Optional, (used on UCH modules) High leaving condenser water temperature
8. Failure of chiller to start or chiller shutdown due to any of the above safety cutouts shall be
enunciated by display of the appropriate diagnostic description at the unit control panel. This
annunciation will be in plain English- Alphanumeric codes shall be unacceptable.

B. The chiller shall be furnished with a Master Controller as an integral portion of the chiller control circuitry
to provide the following functions:

C. Provide automatic chiller shutdown during periods when the load level decreases below the normal
operating requirements of the chiller. Upon an increase in load, the chiller shall automatically restart.

D. Provisions for connection to automatically enable the chiller from a remote energy management system.

E. The control panel shall provide alphanumeric display showing all system parameters in the English
language with numeric data in English units.
PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive chillers for compliance with installation tolerances and other conditions effecting performance and maintenance of chillers.

B. Examine proposed route of moving chillers into place and verify that it is free of interferences.

C. Verify piping roughing-in locations.

D. Verify branch circuit wiring suitability. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install chillers according to manufacturer's written instructions.

B. Install chillers plumb and level, and anchor housekeeping pads to building floor. Anchor chiller and vibration isolators to housekeeping pad.

C. Install vibration isolators according to isolator manufacturer's written instructions.

D. Maintain manufacturer's recommended clearances for service and maintenance.

E. Install piping connections maintaining clearances for service and maintenance of chillers.

F. Install differential pressure switches across heat pump/chilled-water and condenser-water connections.

G. Install flange connections at chillers.

H. Install flexible pipe connections for chillers mounted on vibration isolators.

I. Install MAIN shutoff valves at chiller inlet and outlet of both chilled-water and condenser-water connections.

J. Install BYPASS MAIN shutoff valves which can short-circuit chiller inlet to outlet of both chilled-water and condenser-water connections.

K. Install water strainers as required to the evaporator and condenser water systems.

3.3 ELECTRICAL CONNECTIONS

A. Install all necessary electrical wiring devices and services such as fused disconnect switches or circuit breakers to power each module, phase loss monitors. Install all wires and cables routing between each module and the master controller. Install electrical service to the master control panel. All wiring is done in the field and shall be according to local and national electrical codes where applicable.

B. Install and connect remote flow switches and remote chiller control panel.

C. Ground equipment.
D. Tighten electrical connectors and terminals, including grounding connections, according to manufacturers published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.4 FIELD QUALITY CONTROL
A. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.5 CLEANING
A. Clean finishes to remove dust and dirt.
B. Touch up scratches in unfinished surfaces to restore corrosion resistance.
C. Touch up scratches in finished surfaces to restore finish.

3.6 START-UP
A. Energize chiller and operate controls and safety
B. Verify that motor amperage conforms to manufacturer's data
C. Start chiller and verify performance. Demonstrate operation to Owner.

3.7 DEMONSTRATION
A. Factory-Authorized Startup Services: Engage a factory-authorized service representative to provide start-up services, and to demonstrate and train Owner's maintenance personnel as specified below.
B. Train the Owner's maintenance personnel on procedures and schedules related to startup, shutdown, trouble shooting, servicing, and preventive maintenance.
C. Review data in the operation and maintenance manuals.

3.8 TRAINING
A. Training will be performed for each system installed. Training is to be two separate identical sessions, held on separate weeks. A training Agenda will be developed by the Commissioning Authority. Contractor is responsible to have a competent party perform training, preferably the site foreman in conjunction with manufacturer's representatives.

END OF SECTION 22 35 13
SECTION 22 42 13.13 - COMMERCIAL WATER CLOSETS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Water closets.
   2. Flushometer valves.
   3. Toilet seats.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. LEED Submittals:
   1. Product Data for Prerequisite WE 1, Credit WE 2, and Credit WE 3: Documentation indicating flow and water consumption requirements.

C. Shop Drawings: Include diagrams for power, signal, and control wiring.

1.3 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For flushometer valves and electronic sensors to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 WALL-MOUNTED WATER CLOSETS

A. Water Closets: Wall mounted, top spud.

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

      b. Kohler Co.
      c. Sloan Valve Company.
      d. TOTO USA, INC.

   2. Bowl:

      b. Material: Vitreous china.
      c. Type: Siphon jet.
d. Style: Flushometer valve.
e. Height: Standard.
f. Rim Contour: Elongated.
g. Water Consumption: As noted on plumbing fixture schedule.
h. Spud Size and Location: NPS 1-1/2; top.

3. Flushometer Valve: Provide to match fixture.
4. Toilet Seat: Provide to match fixture.
5. Support:
   a. Standard: ASME A112.6.1M.
   b. Description: Waste-fitting assembly, as required to match drainage piping material and arrangement with faceplates, couplings gaskets, and feet; bolts and hardware matching fixture.
   c. Water-Closet Mounting Height: Standard and Handicapped/elderly according to ICC/ANSI A117.1 as indicated in the plumbing fixture schedule.

2.2 FLUSHOMETER VALVES
A. Lever-Handle, Piston Flushometer Valves: (diaphragm valves will not be considered).
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Moen.
      b. Sloan Valve Company.
   4. Features: Include integral check stop and backflow-prevention device.
   5. Material: Brass body with corrosion-resistant components.
   7. Panel Finish: Chrome plated or stainless steel.

2.3 TOILET SEATS
A. Toilet Seats:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      b. Bemis Manufacturing Company.
      c. Church Seats; Bemis Manufacturing Company.
      d. Kohler Co.
      e. Olsonite Seat Co.
      f. TOTO USA, INC.
      g. Zurn Industries, LLC.
4. Type: Commercial (Heavy duty).
5. Shape: Elongated rim, open front.
6. Hinge: Check.
8. Seat Cover: Not required.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Water-Closet Installation:
   1. Install level and plumb according to roughing-in drawings.
   2. Install floor-mounted water closets on bowl-to-drain connecting fitting attachments to piping or building substrate.
   3. Install accessible, wall-mounted water closets at mounting height for handicapped/elderly, according to ICC/ANSI A117.1.

B. Support Installation:
   1. Install supports, affixed to building substrate, for floor-mounted, back-outlet water closets.
   2. Use carrier supports with waste-fitting assembly and seal.
   3. Install wall-mounted, back-outlet water-closet supports with waste-fitting seals; and affix to building substrate.

C. Flushometer-Valve Installation:
   1. Install flushometer-valve, water-supply fitting on each supply to each water closet.
   2. Attach supply piping to supports or substrate within pipe spaces behind fixtures.
   3. Install lever-handle flushometer valves for accessible water closets with handle mounted on open side of water closet.
   4. Install actuators in locations that are easy for people with disabilities to reach.

D. Install toilet seats on water closets.

E. Wall Flange and Escutcheon Installation:
   1. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations and within cabinets and millwork.
   2. Install deep-pattern escutcheons if required to conceal protruding fittings.
   3. Comply with escutcheon requirements specified in Section 22 05 18 "Escutcheons for Plumbing Piping."

F. Joint Sealing:
   1. Seal joints between water closets and walls and floors using sanitary-type, one-part, mildew-resistant silicone sealant.
   2. Match sealant color to water-closet color.
   3. Comply with sealant requirements specified in Section 07 92 00 "Joint Sealants."
3.2 CONNECTIONS

A. Connect water closets with water supplies and soil, waste, and vent piping. Use size fittings required to match water closets.

B. Comply with water piping requirements specified in Section 22 11 16 "Domestic Water Piping."

C. Comply with soil and waste piping requirements specified in Section 22 13 16 "Sanitary Waste and Vent Piping."

D. Where installing piping adjacent to water closets, allow space for service and maintenance.

3.3 ADJUSTING

A. Operate and adjust water closets and controls. Replace damaged and malfunctioning water closets, fittings, and controls.

B. Adjust water pressure at flushometer valves to produce proper flow.

3.4 CLEANING AND PROTECTION

A. Clean water closets and fittings with manufacturers’ recommended cleaning methods and materials.

B. Install protective covering for installed water closets and fittings.

C. Do not allow use of water closets for temporary facilities unless approved in writing by Owner.

3.5 TRAINING

A. Training will be performed for each system installed. Training is to be two separate identical sessions, held on separate weeks. A training Agenda will be developed by the Commissioning Authority. Contractor is responsible to have a competent party perform training, preferably the site foreman in conjunction with manufacturer’s representatives.

END OF SECTION 22 42 13.13
SECTION 22 42 13.16 - COMMERCIAL URINALS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Urinals.
   2. Flushometer valves.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. LEED Submittals:
   1. Product Data for Prerequisite WE 1, Credit WE 2, and Credit WE 3: Documentation indicating
      flow and water consumption requirements.

C. Shop Drawings: Include diagrams for power, signal, and control wiring.

1.3 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For flushometer valves and electronic sensors to include in operation
   and maintenance manuals.

PART 2 - PRODUCTS

2.1 WALL-HUNG URINALS

A. Urinals: Wall hung, back outlet, washout.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the
      following:
      b. Kohler Co.
      c. TOTO USA, INC.
      d. Zurn Industries, LLC.
   2. Fixture:
      b. Material: Vitreous china.
      c. Type: Washout with extended shields.
      d. Strainer or Trapway: Manufacturer's standard strainer with integral trap.
      e. Water Consumption: Per plumbing fixture schedule.
      f. Spud Size and Location: NPS 3/4, top.
      g. Outlet Size and Location: NPS 2, back.
      h. Color: White.
3. Flushometer Valve: To match urinal
4. Waste Fitting:
   b. Size: NPS 2.
5. Support: ASME A112.6.1M, Type I, urinal carrier with fixture support plates and coupling with seal and fixture bolts and hardware matching fixture.

2.2 URINAL FLUSHOMETER VALVES

A. Battery-Powered, Solenoid-Actuator, Piston Flushometer Valves:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Kohler Co.
      b. Moen Incorporated.
      c. Sloan Valve Company.
      d. TOTO USA, INC.
      e. Zurn Industries, LLC.
   4. Features: Include integral check stop and backflow-prevention device.
   5. Material: Brass body with corrosion-resistant components.
   7. Style: Exposed.
   8. Actuator: Solenoid complying with UL 1951; listed and labeled as defined in NFPA 70, by a qualified testing agency; and marked for intended location and application.
   9. Trip Mechanism: Battery-powered electronic sensor complying with UL 1951; listed and labeled as defined in NFPA 70, by a qualified testing agency; and marked for intended location and application.
   10. Consumption: Per the plumbing fixture schedule.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in of water supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before urinal installation.
B. Examine walls and floors for suitable conditions where urinals will be installed.
C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Urinal Installation:
   1. Install urinals level and plumb according to roughing-in drawings.
   2. Install wall-hung, back-outlet urinals onto waste fitting seals and attached to supports.
3. Install wall-hung, bottom-outlet urinals with tubular waste piping attached to supports.

4. Install accessible, wall-mounted urinals at mounting height for the handicapped/elderly, according to ICC/ANSI A117.1.

5. Install trap-seal liquid in waterless urinals.

B. Support Installation:
1. Install supports, affixed to building substrate, for wall-hung urinals.
2. Use off-floor carriers with waste fitting and seal for back-outlet urinals.
3. Use carriers without waste fitting for urinals with tubular waste piping.
4. Use chair-type carrier supports with rectangular steel uprights for accessible urinals.

C. Flushometer-Valve Installation:
1. Install flushometer-valve water-supply fitting on each supply to each urinal.
2. Attach supply piping to supports or substrate within pipe spaces behind fixtures.
3. Install lever-handle flushometer valves for accessible urinals with handle mounted on open side of compartment.
4. Install fresh batteries in battery-powered, electronic-sensor mechanisms.

D. Wall Flange and Escutcheon Installation:
1. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations.
2. Install deep-pattern escutcheons if required to conceal protruding fittings.
3. Comply with escutcheon requirements specified in Section 22 05 18 "Escutcheons for Plumbing Piping."

E. Joint Sealing:
1. Seal joints between urinals and walls and floors using sanitary-type, one-part, mildew-resistant silicone sealant.
2. Match sealant color to urinal color.
3. Comply with sealant requirements specified in Section 07 92 00 "Joint Sealants."

3.3 CONNECTIONS
A. Connect urinals with water supplies and soil, waste, and vent piping. Use size fittings required to match urinals.

B. Comply with water piping requirements specified in Section 22 11 16 "Domestic Water Piping."

C. Comply with soil and waste piping requirements specified in Section 22 13 16 "Sanitary Waste and Vent Piping."

D. Where installing piping adjacent to urinals, allow space for service and maintenance.

3.4 ADJUSTING
A. Operate and adjust urinals and controls. Replace damaged and malfunctioning urinals, fittings, and controls.

B. Adjust water pressure at flushometer valves to produce proper flow.

C. Install fresh batteries in battery-powered, electronic-sensor mechanisms.
3.5 CLEANING AND PROTECTION

A. Clean urinals and fittings with manufacturers' recommended cleaning methods and materials.

B. Install protective covering for installed urinals and fittings.

C. Do not allow use of urinals for temporary facilities unless approved in writing by Owner.

3.6 TRAINING

A. Training will be performed for each system installed. Training is to be two separate identical sessions, held on separate weeks. A training Agenda will be developed by the Commissioning Authority. Contractor is responsible to have a competent party perform training, preferably the site foreman in conjunction with manufacturer's representatives.

END OF SECTION 22 42 13.16
SECTION 22 42 16.13 - COMMERCIAL LAVATORIES

PART 1 - GENERAL

1.1 SUMMARY
   A. Section Includes:
      1. Lavatories.
      2. Faucets.

1.2 ACTION SUBMITTALS
   A. Product Data: For each type of product.
   B. LEED Submittals:
      1. Product Data for Prerequisite WE 1, Credit WE 2, and Credit WE 3: Documentation indicating flow and water consumption requirements.
   C. Shop Drawings: Include diagrams for power, signal, and control wiring of automatic faucets.

1.3 INFORMATIONAL SUBMITTALS
   A. Coordination Drawings: Counter cutout templates for mounting of counter-mounted lavatories.

1.4 CLOSEOUT SUBMITTALS
   A. Operation and Maintenance Data: For lavatories and faucets to include in operation and maintenance manuals.
      1. In addition to items specified in Section 01 78 23 "Operation and Maintenance Data," include the following:
         a. Servicing and adjustments of automatic faucets.

PART 2 - PRODUCTS

2.1 VITREOUS-CHINA, COUNTER-MOUNTED LAVATORIES
   A. Lavatory: Oval, self rimming, vitreous china, counter mounted.
      1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
2. Fixture:
   b. Type: Self-rimming for above-counter mounting.
   c. Nominal Size: Oval, 18 by 12 inches.
   d. Faucet-Hole Punching: One hole.
   e. Faucet-Hole Location: Top.
   g. Mounting Material: Sealant.


2.2 VITREOUS-CHINA, WALL-MOUNTED LAVATORIES

A. Lavatory: Wheelchair, vitreous china, wall mounted.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   b. Gerber Plumbing Fixtures LLC.
   c. Kohler Co.
   d. Sloan
   e. Zurn Industries, LLC.

2. Fixture:
   b. Type: Slab or wheelchair.
   c. Nominal Size: Rectangular, 27 by 20 inches.
   d. Faucet-Hole Punching: One hole.
   e. Faucet-Hole Location: Top.
   g. Mounting: For concealed-arm carrier.


2.3 SUPPLY FITTINGS

A. NSF Standard: Comply with NSF/ANSI 61, "Drinking Water System Components - Health Effects," for supply-fitting materials that will be in contact with potable water.

B. Standard: ASME A112.18.1/CSA B125.1.
C. Supply Piping: Chrome-plated-brass pipe or chrome-plated copper tube matching water-supply piping size. Include chrome-plated-brass or stainless-steel wall flange.

D. Supply Stops: Chrome-plated-brass, one-quarter-turn, ball-type or compression valve with inlet connection matching supply piping.

E. Operation: [Loose key] [Wheethandle] <Insert type>.

F. Risers:
   1. NPS 1/2.
   2. ASME A112.18.6, braided- or corrugated-stainless-steel, flexible hose riser.

2.4 WASTE FITTINGS

A. Standard: ASME A112.18.2/CSA B125.2.

B. Drain: Grid type with NPS 1-1/4 offset and straight tailpiece.

C. Trap:
   2. Material: Chrome-plated, two-piece, cast-brass trap and swivel elbow with 0.032-inch-thick brass tube to wall; and chrome-plated, brass or steel wall flange.
   3. Material: Stainless-steel, two-piece trap and swivel elbow with 0.012-inch-thick stainless-steel tube to wall; and stainless-steel wall flange.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in of water supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before lavatory installation.

B. Examine counters and walls for suitable conditions where lavatories will be installed.

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

3.2 INSTALLATION

A. Install lavatories level and plumb according to roughing-in drawings.

B. Install supports, affixed to building substrate, for wall-mounted lavatories.

C. Install accessible wall-mounted lavatories at handicapped/elderly mounting height for people with disabilities or the elderly, according to ICC/ANSI A117.1.

D. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons if required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 22 05 18 "Escutcheons for Plumbing Piping."
E. Seal joints between lavatories and counters and walls using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Comply with sealant requirements specified in Section 07 92 00 "Joint Sealants."

F. Install protective shielding pipe covers and enclosures on exposed supplies and waste piping of accessible lavatories. Comply with requirements in Section 22 07 19 "Plumbing Piping Insulation."

3.3 CONNECTIONS

A. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.

B. Comply with water piping requirements specified in Section 22 11 16 "Domestic Water Piping."

C. Comply with soil and waste piping requirements specified in Section 22 13 16 "Sanitary Waste and Vent Piping."

3.4 ADJUSTING

A. Operate and adjust lavatories and controls. Replace damaged and malfunctioning lavatories, fittings, and controls.

B. Adjust water pressure at faucets to produce proper flow.

C. Install fresh batteries in battery-powered, electronic-sensor mechanisms.

3.5 CLEANING AND PROTECTION

A. After completing installation of lavatories, inspect and repair damaged finishes.

B. Clean lavatories, faucets, and other fittings with manufacturers' recommended cleaning methods and materials.

C. Provide protective covering for installed lavatories and fittings.

D. Do not allow use of lavatories for temporary facilities unless approved in writing by Owner.

3.6 TRAINING

A. Training will be performed for each system installed. Training is to be two separate identical sessions, held on separate weeks. A training Agenda will be developed by the Commissioning Authority. Contractor is responsible to have a competent party perform training, preferably the site foreman in conjunction with manufacturer's representatives.

END OF SECTION 22 42 16.13
SECTION 22 42 16.16 - COMMERCIAL SINKS

PART 1 - GENERAL

1.1 SUMMARY
A. Section Includes:
   1. Service basins.
   2. Handwash sinks.
   3. Sink faucets.
   4. Laminar-flow, faucet-spout outlets.
   5. Supply fittings.

1.2 ACTION SUBMITTALS
A. Product Data: For each type of product.
B. LEED Submittals:
   1. Product Data for Prerequisite WE 1, Credit WE 2, and Credit WE 3: Documentation indicating flow and water consumption requirements.

1.3 INFORMATIONAL SUBMITTALS
A. Coordination Drawings: Counter cutout templates for mounting of counter-mounted lavatories.

1.4 CLOSEOUT SUBMITTALS
A. Maintenance data.

PART 2 - PRODUCTS

2.1 SERVICE BASINS
A. Service Basins: Plastic, floor mounted.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Crane Plumbing, L.L.C.
      b. E. L. Mustee & Sons, Inc.
      c. Florestone Products Co., Inc.
      d. FNW; Ferguson Enterprises, Inc.
      e. Fiat.
2. Fixture:
   b. Material: Cast polymer.
   c. Nominal Size: 24 by 24 by 10 inches.
   d. Tiling Flange: Not required.
   e. Rim Guard: On all top surfaces.
   f. Color: Not applicable.
   g. Drain: Grid with NPS 3 outlet.

3. Mounting: On floor and flush to wall.

2.2 HANDWASH SINKS

A. Handwash Sinks: Stainless steel, wall mounted.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Advance Tabco.
   b. AERO Manufacturing Company.
   c. Amtekco Industries, Inc; a Wasserstrom Company.
   d. Eagle Group.
   e. Elkay Manufacturing Co.
   f. Griffin Products, Inc.
   g. Just Manufacturing.

2. Fixture:
   b. Type: Basin with radius corners, back for faucet, and support brackets.
   c. Nominal Size: See Schedule.


2.3 SINK FAUCETS

A. NSF Standard: Comply with NSF/ANSI 61, "Drinking Water System Components - Health Effects," for faucet-spout materials that will be in contact with potable water.

B. Sink Faucets: See Schedule.

1. Commercial, Solid-Brass Faucets:
   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1) American Standard America.
2) Chicago Faucets; Geberit Company.
3) Elkay Manufacturing Co.
4) GROHE America, Inc.
5) Moen Incorporated.
6) T & S Brass and Bronze Works, Inc.

2. General-Duty, Solid-Brass Faucets:
   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1) American Standard America.
      2) Chicago Faucets; Geberit Company.
      3) Elkay Manufacturing Co.
      4) GROHE America, Inc.
      5) Kohler Co.
      6) Moen Incorporated.
      7) T & S Brass and Bronze Works, Inc.

4. General: Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture hole punchings; coordinate outlet with spout and sink receptor.
5. Body Type: .
7. Finish: Chrome plated.
8. Maximum Flow Rate: .
9. Handle(s): Wrist blade, 4 inches.
10. Mounting Type: Deck, concealed.
11. Spout Type: .

2.4 SUPPLY FITTINGS

A. NSF Standard: Comply with NSF/ANSI 61, "Drinking Water System Components - Health Effects," for supply-fitting materials that will be in contact with potable water.

B. Standard: ASME A112.18.1/CSA B125.1.

C. Supply Piping: Chrome-plated brass pipe or chrome-plated copper tube matching water-supply piping size. Include chrome-plated brass or stainless-steel wall flange.

D. Supply Stops: Chrome-plated brass, one-quarter-turn, ball-type or compression valve with inlet connection matching supply piping.

E. Operation: [Loose key] [Wheel handle] <Insert type>.

F. Risers:
   1. NPS 1/2
   2. ASME A112.18.6, braided or corrugated stainless-steel flexible hose.
2.5 WASTE FITTINGS

A. Standard: ASME A112.18.2/CSA B125.2.

B. Drain: Grid type with NPS 1-1/2 offset and straight tailpiece.

C. Trap:
   2. Material: Chrome-plated, two-piece, cast-brass trap and swivel elbow with 0.032-inch thick brass tube to wall; and chrome-plated brass or steel wall flange.
   3. Material: Stainless-steel, two-piece trap and swivel elbow with 0.012-inch thick stainless-steel tube to wall; and stainless-steel wall flange.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in of water supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before sink installation.

B. Examine walls, floors, and counters for suitable conditions where sinks will be installed.

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

3.2 INSTALLATION

A. Install sinks level and plumb according to roughing-in drawings.

B. Install supports, affixed to building substrate, for wall-hung sinks.

C. Install accessible wall-mounted sinks at handicapped/elderly mounting height according to ICC/ANSI A117.1.

D. Set floor-mounted sinks in leveling bed of cement grout.

E. Install water-supply piping with stop on each supply to each sink faucet.
   1. Exception: Use ball or gate valves if supply stops are not specified with sink. Comply with valve requirements specified in Section 22 05 23.12 "Ball Valves for Plumbing Piping" and Section 22 05 23.15 "Gate Valves for Plumbing Piping."
   2. Install stops in locations where they can be easily reached for operation.

F. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons if required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 22 05 18 "Escutcheons for Plumbing Piping."

G. Seal joints between sinks and counters, floors, and walls using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Comply with sealant requirements specified in Section 07 92 00 "Joint Sealants."
H. Install protective shielding pipe covers and enclosures on exposed supplies and waste piping of accessible sinks. Comply with requirements in Section 22 07 19 "Plumbing Piping Insulation."

3.3 CONNECtIONS

A. Connect sinks with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.

B. Comply with water piping requirements specified in Section 22 11 16 "Domestic Water Piping."

C. Comply with soil and waste piping requirements specified in Section 22 13 16 "Sanitary Waste and Vent Piping."

3.4 ADJUSTING

A. Operate and adjust sinks and controls. Replace damaged and malfunctioning sinks, fittings, and controls.

B. Adjust water pressure at faucets to produce proper flow.

3.5 CLEANING AND PROTECTION

A. After completing installation of sinks, inspect and repair damaged finishes.

B. Clean sinks, faucets, and other fittings with manufacturers' recommended cleaning methods and materials.

C. Provide protective covering for installed sinks and fittings.

D. Do not allow use of sinks for temporary facilities unless approved in writing by Owner.

3.6 TRAINING

A. Training will be performed for each system installed. Training is to be two separate identical sessions, held on separate weeks. A training Agenda will be developed by the Commissioning Authority. Contractor is responsible to have a competent party perform training, preferably the site foreman in conjunction with manufacturer's representatives.
SECTION 22 45 00 - EMERGENCY PLUMBING FIXTURES

PART 1 - GENERAL

1.1 SUMMARY
   A. Section Includes:
      1. Water-tempering equipment.

1.2 ACTION SUBMITTALS
   A. Product Data: For each type of product indicated.
   B. Shop Drawings: Diagram power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS
   A. Field quality-control test reports.

1.4 CLOSEOUT SUBMITTALS
   A. Operation and maintenance data.

1.5 QUALITY ASSURANCE
   A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
   B. ANSI Standard: Comply with ANSI Z358.1, "Emergency Eyewash and Shower Equipment."
   C. NSF Standard: Comply with NSF 61, "Drinking Water System Components - Health Effects," for fixture materials that will be in contact with potable water.

PART 2 - PRODUCTS

2.1 WATER-TEMPERING EQUIPMENT
   A. Hot- and Cold-Water, Water-Tempering Equipment:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Acorn Safety.
   b. Armstrong International, Inc.
   c. Bradley Corporation.
   d. Encon Safety Products.
   e. Guardian Equipment Co.
   f. Haws Corporation.
   g. Lawler Manufacturing Company, Inc.
   h. Leonard Valve Company.
   i. Powers.
   j. Speakman Company.
   k. Stingray Systems LLC.

2. Description: Factory-fabricated equipment with thermostatic mixing valve.
   a. Thermostatic Mixing Valve: Designed to provide 85 deg F tepid, potable water at emergency plumbing fixtures, to maintain temperature at plus or minus 5 deg F throughout required 15-minute test period, and in case of unit failure to continue cold-water flow, with union connections, controls, metal piping, and corrosion-resistant enclosure.
   b. Supply Connections: For hot and cold water.

2.2 SOURCE QUALITY CONTROL
   A. Certify performance of emergency plumbing fixtures by independent testing organization acceptable to authorities having jurisdiction.

PART 3 - EXECUTION

3.1 EMERGENCY PLUMBING FIXTURE INSTALLATION
   A. Install fixtures level and plumb.
   B. Fasten fixtures to substrate.

3.2 CONNECTIONS
   A. Connect hot- and cold-water-supply piping to hot- and cold-water, water-tempering equipment. Connect output from water-tempering equipment to emergency plumbing fixtures. Comply with requirements for hot- and cold-water piping specified in Section 22 11 16 "Domestic Water Piping."
   B. Directly connect emergency plumbing fixture receptors with trapped drain outlet to sanitary waste and vent piping. Comply with requirements for waste piping specified in Section 22 13 16 "Sanitary Waste and Vent Piping."
   C. Indirectly connect emergency plumbing fixture receptors without trapped drain outlet to sanitary waste or storm drainage piping.
D. Where installing piping adjacent to emergency plumbing fixtures, allow space for service and maintenance of fixtures.

3.3 IDENTIFICATION

A. Install equipment nameplates or equipment markers on emergency plumbing fixtures and equipment and equipment signs on water-tempering equipment. Comply with requirements for identification materials specified in Section 22 05 53 "Identification for Plumbing Piping and Equipment."

3.4 FIELD QUALITY CONTROL

A. Mechanical-Component Testing: After plumbing connections have been made, test for compliance with requirements. Verify ability to achieve indicated capacities.

B. Tests and Inspections:
   1. Perform each visual and mechanical inspection.
   2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
   3. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation.
   4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Emergency plumbing fixtures and water-tempering equipment will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

3.5 ADJUSTING

A. Adjust or replace fixture flow regulators for proper flow.

B. Adjust equipment temperature settings.

3.6 TRAINING

A. Training will be performed for each system installed. Training is to be two separate identical sessions, held on separate weeks. A training Agenda will be developed by the Commissioning Authority. Contractor is responsible to have a competent party perform training, preferably the site foreman in conjunction with manufacturer’s representatives.

END OF SECTION 22 45 00
SECTION 22 47 16 - PRESSURE WATER COOLERS

PART 1 - GENERAL

1.1 SUMMARY
   A. Section includes pressure water coolers and related components.

1.2 ACTION SUBMITTALS
   A. Product Data: For each type of pressure water cooler.
   B. LEED Submittals:
      1. Product Data for Prerequisite WE 1, Credit WE 2, and Credit WE 3: Documentation indicating flow and water consumption requirements.
   C. Shop Drawings: Include diagrams for power, signal, and control wiring.

1.3 CLOSEOUT SUBMITTALS
   A. Maintenance Data: For pressure water coolers to include in maintenance manuals.

1.4 MAINTENANCE MATERIAL SUBMITTALS
   A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
      1. Filter Cartridges: Equal to 300 percent of quantity installed for each type and size indicated, but no fewer than 3 of each.

PART 2 - PRODUCTS

2.1 PRESSURE WATER COOLERS
   A. Pressure Water Coolers: Wall mounted, standard, wheelchair accessible.
      1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
         a. Elkay Manufacturing Co.
         b. Halsey Taylor.
         c. Haws Corporation.
         d. Larco Inc.
         e. Tri Palm International, LLC.
      2. Cabinet: Bi-level with two attached cabinets, all stainless steel.
      3. Bubbler: One, with adjustable stream regulator, located on each cabinet deck.
      5. Drain: Grid with NPS 1-1/4 tailpiece.
8. Filter: One or more water filters complying with NSF 42 and NSF 53 for cyst and lead reduction to below EPA standards; with capacity sized for unit peak flow rate.
9. Cooling System: Electric, with hermetically sealed compressor, cooling coil, air-cooled condensing unit, corrosion-resistant tubing, refrigerant, corrosion-resistant-metal storage tank, and adjustable thermostat.
   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.
10. Capacities and Characteristics:
   b. Ambient-Air Temperature: 90 deg F.
   c. Inlet-Water Temperature: 80 deg F.
   d. Cooled-Water Temperature: 50 deg F.
   e. Cooled-Water Storage:
   f. Electrical Characteristics:
      1) Volts: 120-V ac.
      2) Phase: Single.
      3) Hertz: 60.
      4) Full-Load Amperes:
      5) Minimum Circuit Ampacity:
      6) Maximum Overcurrent Protection:

PART 3 - EXECUTION

3.1 EXAMINATION
A. Examine roughing-in for water-supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before fixture installation.
B. Examine walls and floors for suitable conditions where fixtures will be installed.
C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION
A. Install fixtures level and plumb according to roughing-in drawings. For fixtures indicated for children, install at height required by authorities having jurisdiction.
B. Install off-the-floor carrier supports, affixed to building substrate, for wall-mounted fixtures.
C. Install water-supply piping with shutoff valve on supply to each fixture to be connected to domestic-water distribution piping. Use ball or gate valve. Install valves in locations where they can be easily reached for operation. Valves are specified in Section 22 05 23.12 "Ball Valves for Plumbing Piping" and Section 22 05 23.15 "Gate Valves for Plumbing Piping."
D. Install trap and waste piping on drain outlet of each fixture to be connected to sanitary drainage system.
E. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons where required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 22 05 18 "Escutcheons for Plumbing Piping."

F. Seal joints between fixtures and walls using sanitary-type, one-part, mildew-resistant, silicone sealant. Match sealant color to fixture color. Comply with sealant requirements specified in Section 07 92 00 "Joint Sealants."

3.3 CONNECTIONS

A. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.

B. Comply with water piping requirements specified in Section 22 11 16 "Domestic Water Piping."

C. Install ball or gate shutoff valve on water supply to each fixture. Install valve upstream from filter for water cooler. Comply with valve requirements specified in Section 22 05 23.12 "Ball Valves for Plumbing Piping" and Section 22 05 23.15 "Gate Valves for Plumbing Piping."

D. Comply with soil and waste piping requirements specified in Section 22 13 16 "Sanitary Waste and Vent Piping."

3.4 ADJUSTING

A. Adjust fixture flow regulators for proper flow and stream height.

B. Adjust pressure water-cooler temperature settings.

3.5 CLEANING

A. After installing fixture, inspect unit. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.

B. Clean fixtures, on completion of installation, according to manufacturer's written instructions.

C. Provide protective covering for installed fixtures.

D. Do not allow use of fixtures for temporary facilities unless approved in writing by Owner.

3.6 TRAINING

A. Training will be performed for each system installed. Training is to be two separate identical sessions, held on separate weeks. A training Agenda will be developed by the Commissioning Authority. Contractor is responsible to have a competent party perform training, preferably the site foreman in conjunction with manufacturer's representatives.

END OF SECTION 22 47 16

PRESSURE WATER COOLERS
SECTION 22 66 00 - CHEMICAL-WASTE SYSTEMS FOR LABORATORY AND HEALTHCARE FACILITIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

2. Piping specialties.

1.2 PERFORMANCE REQUIREMENTS

A. Single-Wall Piping Pressure Rating: 10 feet head of water.

B. Delegated Design: Design seismic restraints for aboveground piping, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

1.3 ACTION SUBMITTALS

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

B. LEED Submittals:

1. Product Data for Credit IEQ 4.1: For solvent cements and adhesive primers, documentation including printed statement of VOC content.
2. Laboratory Test Reports for Credit IEQ 4: For solvent cements and adhesive primers, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. Shop Drawings: For leak-detection system. Include plans, elevations, sections, details, and attachments to other work.

1. Detail leak-detection-system assemblies and indicate required clearances, method of field assembly, components, and location and size of each field connection.
2. Wiring Diagrams: For power, signal, and control wiring.

D. Delegated-Design Submittal: For seismic restraints of aboveground piping, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control test reports.
PART 2 - PRODUCTS

2.1 SINGLE-WALL PIPE AND FITTINGS


B. Piping MUST MEET ASTE E84 for use in a plenum, having a flame and smoke spread rating of less than 25/50.

C. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Orion Fittings; a Watts Water Technologies company.
   2. Watts; a Watts Water Technologies company.
   3. Zurn Industries, LLC.

2.2 PIPING SPECIALTIES

A. Plastic Dilution Traps:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Georg Fischer Inc.
      b. IPEX USA LLC.
      c. Orion Fittings; a Watts Water Technologies company.
      d. Town & Country Plastics, Inc.
      e. Zurn Industries, LLC.

   3. End Connections: Mechanical joint.
   4. Dilution Tanks: 1-gal. capacity, with clear base unless colored base is indicated; with two NPS 1-1/2 top inlets and one NPS 1-1/2 side outlet.
   5. Small Dilution Jars: 1-pint capacity, with clear base unless colored base is indicated; with NPS 1-1/2 top inlet and NPS 1-1/2 side outlet.
   6. Large Dilution Jars: 1-quart capacity; with NPS 1-1/2 top inlet and NPS 1-1/2 side outlet.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Comply with requirements in Section 31 20 00 "Earth Moving" for excavating, trenching, and backfilling.

3.2 PIPING INSTALLATION

A. Chemical-Waste Piping Inside the Building:
   1. Install piping next to equipment, accessories, and specialties to allow service and maintenance.
2. Transition and special fittings with pressure ratings at least equal to piping pressure rating may be used unless otherwise indicated.
3. Flanges may be used on aboveground piping unless otherwise indicated.
4. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
5. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
6. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
7. Install piping at indicated slopes.
8. Install piping free of sags and bends.
9. Install fittings for changes in direction and branch connections.
10. Verify final equipment locations for roughing-in.
11. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 22 05 17 "Sleeves and Sleeve Seals for Plumbing Piping."
12. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 22 05 17 "Sleeves and Sleeve Seals for Plumbing Piping."
13. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 22 05 18 "Escutcheons for Plumbing Piping."

3.3 PIPING SPECIALTY INSTALLATION

A. Install cleanouts and riser extension from sewer pipe to cleanout at grade. Use fittings of same material as sewer pipe at branches for cleanouts and riser extensions to cleanouts. Install piping so cleanouts open in direction of flow in pipe.

1. Set cleanout bodies in earth in cast-in-place concrete block, 18 by 18 by 12 inches deep. Set with tops 1 inch above surrounding grade. Set cleanout plugs in concrete pavement with tops flush with pavement surface. Comply with requirements in Section 03 30 00 "Cast-in-Place Concrete" for formwork, reinforcement, and concrete requirements.

3.4 JOINT CONSTRUCTION

A. Chemical-Waste Piping Inside the Building:

1. Plastic-Piping Electrofusion Joints: Make polyolefin drainage-piping joints according to ASTM F 1290.
2. Dissimilar-Material Piping Joints: Make joints using adapters compatible with both system materials.
5. PVC Nonpressure Piping Joints: Join piping according to ASTM D 2665.

3.5 HANGER AND SUPPORT INSTALLATION

A. Pipe sizes in this article refer to aboveground, single-wall piping and carrier piping of containment piping.

B. Comply with requirements in Section 22 05 48 "Vibration and Seismic Controls for Plumbing Piping and Equipment" for seismic-restraint devices.
C. Comply with requirements in Section 22 05 29 "Hangers and Supports for Plumbing Piping and Equipment" for pipe hanger and support devices. Install the following:

1. Vertical Piping: MSS Type 8 or MSS Type 42, riser clamps.
2. Individual, Straight, Horizontal Piping Runs:
   a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
   b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
   c. Longer Than 100 Feet, if Indicated: MSS Type 49, spring cushion rolls.
3. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
4. Base of Vertical Piping: MSS Type 52, spring hangers.

D. Comply with requirements in Section 22 05 29 "Hangers and Supports for Plumbing Piping and Equipment" for installation of supports.

E. Support horizontal piping and tubing within 12 inches of each fitting and coupling.

F. Support vertical piping and tubing at base and at each floor.

G. Rod diameter may be reduced 1 size for double-rod hangers, to minimum of 3/8 inch.

H. Install vinyl-coated hangers for PVDF piping with the following maximum horizontal spacing and minimum rod diameters:

1. All Sizes: Install continuous support for piping with liquid waste at temperatures above 140 deg F.
2. NPS 1/2 and Smaller: 30 inches with 3/8-inch rod.
3. NPS 3/4 to NPS 1-1/2: 36 inches with 3/8-inch rod.
4. NPS 2: 36 inches with 3/8-inch rod.
5. NPS 2-1/2 and NPS 3: 42 inches with 1/2-inch rod.
6. NPS 4 and NPS 5: 48 inches with 5/8-inch rod.
7. NPS 6: 48 inches with 3/4-inch rod.

I. Install supports for vertical PVDF piping NPS 1-1/2 every 48 inches and NPS 2 and larger every 72 inches.

3.6 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Make connections to existing piping so finished Work complies as nearly as practical with requirements specified for new Work.

C. Use commercially manufactured wye fittings for sewerage piping branch connections. Remove section of existing pipe; install wye fitting into existing piping; and encase entire wye fitting plus 6-inch overlap, with not less than 6 inches of concrete with 28-day compressive strength of 3000 psi.

D. Protect existing piping to prevent concrete or debris from entering while making connections. Remove debris or other extraneous material that may accumulate.

E. Install piping adjacent to equipment to allow service and maintenance.
3.7 LABELING AND IDENTIFICATION

A. Comply with requirements in Section 22 05 53 "Identification for Plumbing Piping and Equipment" for labeling of equipment and piping.

3.8 FIELD QUALITY CONTROL

A. Inspect interior of sewerage piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24 inches of backfill is in place and again at completion of Project.

1. Defects requiring correction include the following:
   a. Alignment: Less than full diameter of inside of pipe is visible between inspection points.
   b. Deflection: Flexible piping with deflection that prevents passage of ball or cylinder of size not less than 92.5 percent of piping diameter.
   c. Crushed, broken, cracked, or otherwise damaged piping.
   d. Hydrostatic Tests for Drainage Piping:
      1) Allowable leakage is a maximum of 50 gal./inch of nominal pipe size per mile of pipe, during 24-hour period.
      2) Close openings in system and fill with water.
      3) Purge air and refill with water.
      4) Disconnect water supply.
      5) Test and inspect joints for leaks.
   e. Air Tests for Drainage Piping: Comply with UNI-B-6.

2. Leaks and loss in test pressure constitute defects that must be repaired.
3. Submit separate reports for each test.

B. Replace leaking sewerage piping using new materials, and repeat testing until leakage is within allowances specified.

C. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

D. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

E. Tests and Inspections:

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect assembled leak-detection systems and their installation, including piping and electrical connections, and to assist in testing.
2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

F. Chemical-waste piping will be considered defective if it does not pass tests and inspections.
G. Prepare test and inspection reports.

3.9 CLEANING

A. Use procedures prescribed by authorities having jurisdiction or, if not prescribed, use procedures described below:

1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
2. Clean piping by flushing with potable water.

3.10 PIPING SCHEDULE

A. Transition and special fittings with pressure ratings at least equal to piping pressure rating may be used in applications below unless otherwise indicated.

B. Aboveground Chemical-Waste Piping: Use the following piping materials for each size range:

1. NPS 1-1/2 to NPS 6: PVDF drainage piping and electrofusion joints.

C. Under Slab-on-Grade, Indoor, Chemical-Waste Piping: Use the following piping materials for each size range:

1. NPS 1-1/2 to NPS 6: PVDF drainage piping and electrofusion joints.

3.11 TRAINING

A. Training will be performed for each system installed. Training is to be two separate identical sessions, held on separate weeks. A training Agenda will be developed by the Commissioning Authority. Contractor is responsible to have a competent party perform training, preferably the site foreman in conjunction with manufacturer’s representatives.

END OF SECTION 22 66 00
SECTION 23 00 00 - MECHANICAL GENERAL REQUIREMENTS

PART 1 - GENERAL

1.1 MECHANICAL REQUIREMENTS

A. The mechanical requirements are supplemental to the General Requirements of these Specifications. The Mechanical Sections shall apply to phases of the work specified, shown on the Drawings, or required to provide for the complete installation of Mechanical Systems for this project.

B. The work shall include all items, articles, materials, operations and methods listed, mentioned, or scheduled in these specifications and the accompanying drawings. All material, equipment, and labor shall be furnished together with all incidental items required by good practice to provide the complete systems described.

C. Examine and refer to all Architectural, Civil, Structural, Electrical, Utility, Landscape and Mechanical drawings and specifications for construction conditions which may affect the mechanical work. Inspect the building site and existing facilities for verification of present conditions. Make proper provisions for these conditions in performance of the work and cost thereof.

D. See general requirements for listed Alternate Bids. Note alternates listed and include any changes in work and price required to meet the requirements of the respective alternate.

1.2 LEED REQUIREMENTS

A. LEED requirements for this project are as follows:

1. Meet LEED standards for all LEED prerequisites and the particular LEED Credits chosen as part of this project. The Following items are only a portion of the LEED points being pursued.
2. Meet ASHRAE 90.1-2007 in all respects for material and methods (this is a requirement of LEED Credit EA-1.0 Optimize Energy Efficiency). These requirements are included throughout the specification.
3. LEED Credit EQ4.1 requires that Adhesives and Sealants be low in VOC’s. See Piping Specifications for VOC content limitations. Submit this information as part of the Shop Drawings.
4. LEED EA Prerequisite 1 and Credits 3 are included and consist of Commissioning of Building Energy Systems. The mechanical contractor shall be responsible for accommodating the commissioning agent in his work. See the Commissioning Specifications.
5. LEED EA Prerequisite 3 and Credit 4 are being pursued. This includes Refrigeration Management directed at reducing impact of refrigerant on the atmosphere. Specific refrigerants are specified to reduce this. Refrigerant substitutions will be disallowed or carefully scrutinized for this reason.
6. Note the specific requirements of EQ Credit 3.1: Construction IAQ during construction. Work shall be done in accordance with SMACNA’s IAQ Guidelines for Occupied Buildings Under Construction, 1995, Chapter 3. Reference this manual for measures to protect the building workers and the building HVAC system during construction and demolition activities. Keep a copy of this standard on site for reference throughout the project.
7. Please refer to Section 01 81 13.13 for Sustainable Design Requirements.

1.3 CODES AND STANDARDS
A. Work shall meet the requirements of the plans and specifications and shall not be less than the minimum requirements of applicable sections of the latest Codes and Standards of the following Organizations:

1. American Gas Association (AGA)
2. American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE)
3. American Society of Mechanical Engineers (ASME)
4. American Water Works Association (AWWA)
5. National Electrical Code (NEC)
6. National Electrical Manufacturers Association (NEMA)
7. National Fire Protection Association (NFPA)
8. Uniform Plumbing Code
9. Occupational Safety & Health Act (OSHA)
10. Plastic Pipe Institute (PPI)
11. Sheet Metal and Air Conditioning Contractors National Association (SMACNA)
12. International Mechanical Code (IMC)
14. Requirements of the Serving Utility Company
15. Local and State Codes and Ordinances
16. SMACNA Seismic Manual

1.4 FEES AND PERMITS

A. The Mechanical Contractor shall pay all fees and arrange for all permits required for work done under his contract and under his supervision by subcontract.

B. All usage contracts between the Owner and the serving utilities company, such as membership and usage charges or fees, etc., for the purpose of obtaining the services for the utility company shall be applied for and paid for by the Owner.

C. All permits and fees for connection to the utility, including inspection and staking costs imposed by the utility company or required for proper installation, and all necessary manholes, encasements, valves, service boxes, meters, meter housings or vaults complete as required by the utility company of jurisdictional agency, shall be applied for and paid by the Mechanical Contractor.

1.5 MATERIALS AND EQUIPMENT

A. Manufacturers trade names and catalog numbers listed are intended to indicate the quality of equipment or materials desired. Manufacturers not listed must have prior approval. Written prior approval must be obtained from the Architect/Engineer ten (10) days prior to bid opening. Requests are to be submitted sufficiently ahead of the deadline to give ample time for examination. The items approved will be listed in an addendum and only this list of equipment will be accepted in lieu of specified products. Submittals must indicate the specific item or items to be furnished in lieu of those specified, together with complete technical and comparative data on specified items and proposed items. See list of prior approved manufacturers at end of this section.

B. Mechanical equipment may be installed with manufacturer’s standard finish and color except where specific color, finish or choice is indicated. If the manufacturer has no standard finish, equipment shall have a prime coat and two finish coats of gray enamel.

C. This Contractor shall be responsible for materials and equipment installed under this contract. Contractor shall also be responsible for the protection of materials and equipment of others from damage as a result of his work.
D. Manufactured material and equipment shall be applied, installed, connected, erected, used, cleaned and conditioned as directed by manufacturer unless herein specified to the contrary.

E. This Contractor shall make the required arrangement with General Contractor for the introduction into the building of equipment too large to pass through finished openings.

F. Store materials and equipment indoors at the job site or, if this is not possible, store on raised platforms and protect from the weather by means of waterproof covers. Coverings shall permit circulation of air around the materials to prevent condensation of moisture. Screen or cap openings in equipment to prevent the entry of vermin.

1.6 INTENT OF DRAWINGS

A. The drawings are partly diagrammatic and do not necessarily show exact location of piping and ductwork unless specifically dimensioned. Riser and other diagrams are schematic and do not necessarily show the physical arrangement of the equipment. They shall not be used for obtaining lineal runs of piping or ductwork, nor shall they be used for shop drawings for piping and ductwork fabrication or ordering. Discrepancies shown on different plans, or between plans and actual field conditions shall be brought to the attention of the Architect/Engineer for resolution.

1.7 RESPONSIBILITY

A. The Mechanical Contractor shall be responsible for the installation of a satisfactory and complete system in accordance with the intent of the drawing and specifications. Provide, at no extra cost, all incidental items required for completion of the work even though they are not specifically mentioned or indicated on the drawings or in the specifications.

B. The drawings do not attempt to show complete details of the building construction which affect the mechanical installation; and reference is therefore required to the Architectural, Civil, Structural, Landscape and Electrical drawings and specifications and to shop drawings of all trades for additional details which affect the installation of the work covered under this Division of the Contract.

C. Location of mechanical system components shall be checked for conflicts with openings, structural members and components of other systems having fixed locations. In the event of any conflicts, the Architect/Engineer shall be consulted and his decision shall govern. Necessary changes shall be made at the Contractor’s expense.

D. Determine, and be responsible for, the proper location and character of inserts for hangers, chases, sleeves, and other openings in the construction required for the work, and obtain this information well in advance of the construction progress so work will not be delayed.

E. Final location of inserts, hangers, etc., required for each installation, must be coordinated with facilities required for other installations to prevent interference.

F. Take extreme caution not to install work that connects to equipment until such time as complete Shop Drawings of such equipment have been approved by the Architect/Engineer. Any work installed by the Contractor, prior to approval of Shop Drawings, will be at the Contractor's risk.

G. At all times during the performance of this Contract, properly protect work from damage and protect the Owner's property from injury of loss. Make good any damage, injury or loss, except such as may be directly due to errors in the Bidding Documents or caused by Agents or Employees of the Owner. Adequately protect adjacent property as provided by law and the Bidding Documents. Provide and
maintain passageways, guard fences, lights and other facilities for protection required by Public Authority or Local conditions.

H. The Contractor shall be responsible for damages due to the work of their Contractors, to the building or its contents, people, etc.

1.8 REVIEW

A. All work and material is subject to review at any time by the Architect/Engineer or his representative. If the Architect/Engineer or his representative finds material that does not conform with these specifications or that is not properly installed or finished, correct the deficiencies in a manner satisfactory to the Architect/Engineer at the Contractor's expense.

1.9 WORKMANSHIP

A. GENERAL

1. Work under this contract shall be performed by workmen skilled in the particular trade, including work necessary to properly complete the installation in a workmanlike manner to present a neat and finished appearance.

B. EXCAVATION AND BACKFILL

1. Provide all excavating and backfilling as required, with backfilling only after approval of the Architect. Backfill to be free of all debris and decayable matter. See Excavation and Backfill requirements in DIVISION 31 – EARTH MOVING.

C. CUTTING, PATCHING, AND FRAMING

1. Obtain Architect's/Engineer's approval before performing any cutting on structural members or patching of building surfaces. Any damage to the building or equipment by this Contractor shall be the responsibility of this Contractor and shall be repaired by skilled craftsmen of the trades involved at the Contractor's expense.

2. Chases, openings, sleeves, hangers, anchors, recesses, equipment pads, framing for equipment, provided by others only if so noted on the drawings. Otherwise, they will be provided by this Contractor for his work. Whether chases, etc., are provided by this Contractor or others, this Contractor is responsible for correct size and locations.

1.10 COORDINATION

A. This Contractor shall plan his work to proceed with a minimum interference with other trades and it shall be his responsibility to inform the General Contractor of all openings required in the building structure for installation of work, and to provide sleeves as required. Dimensions of equipment installed and/or provided by others shall be checked in order that correct clearances and connections may be made.

1.11 CLEAN UP

A. Keep the premises free from accumulation of waste material or rubbish caused by his work or employees.
B. Upon completion of work, remove materials, scraps and debris relative to his work and leave the premises, including tunnels, crawl spaces, and pipe chases in clean and orderly condition. Remove all dirt and debris from the interior and exterior of all devices and equipment. After construction is completed, wash all mechanical equipment.

1.12 DUST PROTECTION

A. Contractor will provide suitable dust protection for all existing areas prior to beginning of cutting or demolition. Contractor will obtain approval of partition from Owner before proceeding with work involved in these rooms.

1.13 TEMPORARY FACILITIES

A. OFFICES

1. Contractor shall provide a temporary office for himself and for the periodic use by the Architect/Engineer including:
   a. Lights, heat, and telephone. (Pay telephone not permitted.)

B. REMOVAL

1. Contractor shall completely remove his temporary installations when no longer needed and the premises shall be completely clean, disinfected, patched, and refinished to match adjacent areas.

C. LADDERS AND SCAFFOLDS

1. The Contractor shall provide their own ladders, scaffolds, etc. of substantial construction for access to their work in various portions of the building as may be required. When no longer needed, they shall be removed by the Contractor.

D. PROTECTION DEVICES

1. The Contractor shall provide and maintain his own necessary barricades, fences, signal lights, etc., required by all governing authorities or shown on the drawings. When no longer needed, they shall be removed by the Contractor. The Contractor shall assume all responsibility for which the Owner may be held responsible because of lack of above items.

E. TEMPORARY WATER

1. The Contractor shall provide all water required by his trade for construction. Temporary drinking water shall be provided by Contractor from a proven safe source dispensed by single service containers, until such time as the construction water outlet has been installed, disinfected, and approved for drinking purposes.

F. TEMPORARY FIRE PROTECTION

1. The Contractor shall provide all necessary first-aid hand fire extinguishers for Class A, B, C and special hazards as may exist in his own work area only in accordance with good and safe practice and as required by jurisdictional safety authority. The Contractor shall provide general area fire extinguishers only.
1.14 SHOP DRAWINGS

A. Provide PDF’s of manufacturer’s literature and/or certified prints as soon as possible but within thirty (30) days after awarding of Contract, for items of materials, equipment, or systems where called for in specifications. Shop drawings and literature complete showing item used, size, dimensions, capacity, rough-in, etc., as required for complete check and installation. Manufacturers literature showing more than one item shall be clearly marked as to which item is being furnished or it will be rejected and returned without review.

B. Each copy of each item submitted must be clearly marked as follows for purposes of identification and record. Submittals not marked (typewritten only) as described below will be rejected and returned without review.

Date:
Name of Project:
Branch of Work:
Submitted by:
Specification or Plan Reference:

C. Prior to their submission, each submittal shall be thoroughly checked by the Contractor for compliance with the Contract Document requirements, accuracy of dimensions, relationship to the work of other trades, and conformance with sound, safe practices as to erection and installation. Each submittal shall then bear a stamp evidencing such checking and shall show corrections made, if any. Submittals requiring extensive corrections shall be revised before submission. Each submittal not stamped and signed by the Contractor evidencing such checking will be rejected and returned without review.

D. All submittals will be examined when submitted in proper form for compliance. Such review shall not relieve the Contractor of responsibility for errors, for deviation from the contract Documents, nor for violation of sound safety practices.

E. The Contractor shall keep in the field office one print of each submittal which has been reviewed and stamped by the Architect or Engineer.

F. Submittals will be required for each item of material and equipment furnished as noted in specifications.

G. Submittals which are incomplete relative to quality requirements, capacity, engineering data, dimensional data or detailed list of specialty or control equipment will be rejected. Lists shall include descriptive coding as specified or shown on drawings.

THE ENGINEER WILL PERFORM SHOP DRAWING REVIEW OF EACH ITEM; HOWEVER, SUBSEQUENT REVIEW OF ITEMS PREVIOUSLY REJECTED WILL BE BILLED TO THE CONTRACTOR AT A RATE OF $140 PER HOUR.

H. Schedule of Shop Drawings.

1. 23 05 16 EXPANSION FITTINGS AND LOOPS FOR HVAC PIPING
2. 23 05 17 SLEEVES AND SLEEVE SEALS FOR HVAC PIPING
3. 23 05 18 ESCUTCHEONS FOR HVAC PIPING
4. 23 05 19 METERS AND GAGES FOR HVAC PIPING
5. 23 05 23.12 BALL VALVES FOR HVAC PIPING
6. 23 05 23.14 CHECK VALVES FOR HVAC PIPING
7. 23 05 23.15 GATE VALVES FOR HVAC PIPING
8. 23 05 29 HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT
9. 23 05 48 VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT
10. 23 05 53 IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT
11. 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC
12. 23 07 13 DUCT INSULATION
13. 23 07 19 HVAC PIPING INSULATION
14. 23 08 00 COMMISSIONING OF HVAC
15. 23 08 50 ATRIUM SMOKE CONTROL SYSTEM SPECIAL INSPECTION AND COMMISSIONING
16. 23 09 23 DIRECT DIGITAL CONTROL (DDC) SYSTEM FOR HVAC
17. 23 09 23.11 CONTROL VALVES
18. 23 09 23.12 CONTROL DAMPERS
19. 23 09 23.13 ENERGY METERS
20. 23 09 23.14 FLOW INSTRUMENTS
21. 23 09 23.16 GAS INSTRUMENTS
22. 23 09 23.17 LEVEL INSTRUMENTS
23. 23 09 23.22 POSITION INSTRUMENTS
24. 23 09 23.23 PRESSURE INSTRUMENTS
25. 23 09 23.24 SPEED INSTRUMENTS
26. 23 09 23.27 TEMPERATURE INSTRUMENTS
27. 23 09 23.43 WEATHER STATIONS
28. 23 09 93.11 SEQUENCE OF OPERATIONS FOR HVAC DDC
29. 23 21 13 HYDRONIC PIPING
30. 23 21 13.33 GROUND-LOOP HEAT-PUMP PIPING
31. 23 21 16 HYDRONIC PIPING SPECIALTIES
32. 23 21 23 HYDRONIC PUMPS
33. 23 22 13 STEAM AND CONDENSATE HEATING PIPING
34. 23 22 16 STEAM AND CONDENSATE PIPING SPECIALTIES
35. 23 22 23 STEAM CONDENSATE PUMPS
36. 23 25 13 WATER TREATMENT FOR CLOSED-LOOP HYDRONIC SYSTEMS
37. 23 31 13 METAL DUCTS
38. 23 33 00 AIR DUCT ACCESSORIES
39. 23 34 16 CENTRIFUGAL HVAC FANS
40. 23 34 23 HVAC POWER VENTILATORS
41. 23 36 00 AIR TERMINAL UNITS
42. 23 37 13 DIFFUSERS, REGISTERS, AND GRILLES
43. 23 37 23 HVAC GRAVITY VENTILATORS
44. 23 72 00 AIR-TO-AIR ENERGY RECOVERY EQUIPMENT
45. 23 73 13 MODULAR INDOOR CENTRAL-STATION AIR-HANDLING UNITS
46. 23 81 46.13 WATER-TO-AIR HEAT PUMPS
47. 23 82 36 FINNED-TUBE RADIATION HEATERS
48. 23 82 39.13 CABINET UNIT HEATERS

I. Submittals shall be properly bound in a PDF or equivalent method. Incomplete submittals shall be returned without review.

1.15 OPERATION AND MAINTENANCE MANUALS

A. At the time orders are placed for any item of equipment requiring service or operating maintenance, the Contractor shall request the manufacturer furnish three (3) copies of OPERATION AND MAINTENANCE INSTRUCTIONS for each piece of equipment. These shall be included in the brochure of equipment.

1.16 BROCHURE OF EQUIPMENT

A. Upon completion of work, prepare three copies of “Brochure of Equipment” containing data pertinent to equipment and systems on job. Binders containing materials shall be one or more three ring binders of sufficient number to hold all literature. Contained in binders shall be: Installation, maintenance, and operating instructions for each piece of equipment; parts lists; wiring diagrams; one copy of each shop drawing and literature submittal; record drawings, etc.
B. All literature shall be clean, unused and filed under divider headings corresponding to the specifications.

C. Provide a thumb drive containing a bound indexed PDF of the brochure of equipment.

D. These brochures shall be submitted to the Architect/Engineer and approved by him before authorization of final payment.

1.17 AS-BUILT DRAWINGS

A. The Contractor shall furnish to the Owner and Architect/Engineer a marked print and scans of the print (.tif format) showing the location of all concealed or underground pipe or conduit runs and other equipment installed other than as shown on the drawings. Dimension underground lines from established building lines. Indicate all installed pull boxes in conduit runs.

B. The Contractor shall furnish to the Architect/Engineer a marked print showing the location of all mechanical equipment, plumbing fixtures, piping, ductwork, diffusers, grilles, etc. The location of any item which deviates from the bid documents shall be accurately drawn and dimensioned.

C. All underground piping and ductwork shall be dimensioned from nearest column and/or exterior walls. The location of all maintenance related items such as duct access doors, fire dampers, isolation valves, filters, etc., shall be highlighted on as built drawing.

1.18 PLACING SYSTEMS IN OPERATION

A. At the completion of the work and at such time as the Owner shall direct, prior to final acceptance, the Contractor performing this work shall put into satisfactory operation the various systems installed under the specifications. At no additional cost to the Owner, furnish the services of a person completely familiar with the installations performed under this specification, to instruct the Owner’s operating personnel in the proper operation and servicing of the equipment and systems. These services shall be available for a period of no less than one (1) day.

1.19 WARRANTY

A. The Contractor shall guarantee that all materials and labor installed are new and of first quality and that any material or labor found defective shall be replaced without cost to the Owner within one (1) year after substantial completion of the Contract or one (1) full season of heating and cooling operation, whichever is the greater. The guarantee shall list the date of the beginning of the one (1) year period, which shall be the date that the Substantial Completion Certificate is issued.

B. Any damage to the building, caused by defective work or material of the Contractor within the above-mentioned period, shall be satisfactorily repaired without cost to the Owner.

C. The guarantee does not include maintenance of equipment. The Owner shall accept full responsibility for proper operation and maintenance of equipment immediately upon substantial completion and occupancy of the building.

D. Final acceptance by the Owner will not occur until all operating instructions are mounted in Equipment Rooms and Operating Personnel thoroughly indoctrinated in the operation of all mechanical equipment by the Contractor.
E. Any equipment, including heat exchangers, boilers, pumps, air handlers, motors, etc., used for temporary heat, shall be brought up to a new condition before final acceptance by the Owner and shall be guaranteed by the Contractor as new equipment.

END OF SECTION 23 00 00
SECTION 23 01 00 - OWNER TRAINING

PART 1 - GENERAL

1.1 SUMMARY

A. Training:

1. General:

a. The system training is intended to familiarize the Owner's operating and maintenance staff with all systems requiring maintenance. Training is to be provided after the systems are in place and operational, after issues noted during the Demonstration have been resolved, and before final acceptance.

b. Provide second set of training sessions for automatic control systems about 6-9 months after the first sessions.

2. Systems Requiring Training:

a. All mechanical, electrical, safety, standby, and automatic control systems in the project, and other systems specified elsewhere to have training.

3. Attendance:

a. Training is to be provided by contractor's representatives that are familiar with the system's operation and maintenance requirements. Individual training sessions (modules) are to be provided for each type or group of systems, separated roughly by trade group that will be performing maintenance on the system. MSU trades groups and systems typically requiring training are:

1) Electricians (Power, lighting, fire alarm and detection, standby power systems)
2) Grounds Maintenance (Grounds surfaces, lawn sprinkler systems)
3) Heating Plant (Hydronic and steam heating systems, fan systems, controls)
4) Plumbers (Plumbing, gas-fired heating, lawn sprinkler systems, fire sprinklers, miscellaneous process piping systems)
5) Refrigeration (Refrigeration, chilled water, packaged cooling systems)

4. Schedule:

a. Duplicate training sessions are to be provided for each training module, so that Owner's operating personnel can be split into two groups during training. Duplicate training sessions to be scheduled on different days. Length of training sessions will be determined by scope of training indicated below, and as coordinated with Owner after draft copy of training documents have been reviewed.

1) Exceptions: Vendors from out of state, with owner approval, may have two sessions in the same week with mandatory video taping of training by vendor or Mechanical contractor.
1. Training Documentation:
   a. Contractor to submit draft copy of agenda and training documents to Owner and CxA for review at least two weeks prior to training date.
   b. Provide a copy of the following items for each person that will be attending the training sessions. Coordinate required number with the Owner.
      1) Training agenda.
      2) Summary of new systems and existing systems affected by this project.
      3) Summary of work performed under this project.
      4) Control system drawings and sequences of operation.
      5) List of important maintenance and trouble-shooting operations for all systems.
   c. Provide minimum of 2 copies of following items:
      1) Contract documents including all drawings, specifications, addendums, and change orders.

2. Training Sessions:
   a. Assemble at location to be determined by the Owner.
   b. Distribute training documentation as indicated above.
   c. Provide classroom style training if required for orientation, discussion of new systems and existing systems affected by this project, and other issues appropriate for a classroom format.
   d. Visit site and review locations, and perform detailed review of operation and maintenance requirements for current systems.

END OF SECTION 23 01 00
SECTION 23 05 00 - COMMON WORK RESULTS FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Piping materials and installation instructions common to most piping systems.
2. Dielectric fittings.
3. Mechanical sleeve seals.
4. Sleeves.
5. Escutcheons.
7. HVAC demolition.
8. Equipment installation requirements common to equipment sections.
9. Concrete bases.
10. Supports and anchorages.

1.2 DEFINITIONS

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

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

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

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

E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

1.3 SUBMITTALS

A. Welding certificates.

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

PART 2 - PRODUCTS

2.1 PIPE, TUBE, AND FITTINGS
A. Refer to individual Division 23 piping Sections for pipe, tube, and fitting materials and joining methods.
B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.2 JOINING MATERIALS
A. Refer to individual Division 23 piping Sections for special joining materials not listed below.
B. Pipe-Flange Gasket Materials: ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.
C. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.
D. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.
E. Brazing Filler Metals: AWS A5.8, BCuP Series or BAg1, unless otherwise indicated.
G. Solvent Cements for Joining Plastic Piping:
   1. CPVC Piping: ASTM F 493.
   2. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.

2.3 DIELECTRIC FITTINGS
A. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.
B. Insulating Material: Suitable for system fluid, pressure, and temperature.
C. Dielectric Unions: Factory-fabricated, union assembly, for 250-psig minimum working pressure at 180 deg F.

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

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

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

2.4 MECHANICAL SLEEVE SEALS

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

B. Sealing Elements: EPDM interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.

C. Pressure Plates: Stainless steel. Include two for each sealing element.

D. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.5 SLEEVES

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

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

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

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

1. Underdeck Clamp: Clamping ring with set screws.

E. Molded PVC: Permanent, with nailing flange for attaching to wooden forms.


G. Molded PE: Reusable, PE, tapered-cup shaped, and smooth-outer surface with nailing flange for attaching to wooden forms.

2.6 ESCUTCHEONS

A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.
B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished chrome-plated finish.

C. One-Piece, Cast-Brass Type: With set screw.
   1. Finish: Polished chrome-plated.

D. Split-Casting, Cast-Brass Type: With concealed hinge and set screw.
   1. Finish: Polished chrome-plated.

2.7 GROUT

A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.
   2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 HVAC DEMOLITION

A. Refer to Division 01 Section "Cutting and Patching" and Division 02 Section "Selective Structure Demolition" for general demolition requirements and procedures.

B. Disconnect, demolish, and remove HVAC systems, equipment, and components indicated to be removed.
   1. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
   2. Piping to Be Abandoned in Place: Drain piping and cap or plug piping with same or compatible piping material.
   3. Ducts to Be Removed: Remove portion of ducts indicated to be removed and plug remaining ducts with same or compatible ductwork material.
   4. Ducts to Be Abandoned in Place: Cap or plug ducts with same or compatible ductwork material.
   5. Equipment to Be Removed: Disconnect and cap services and remove equipment.
   6. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
   7. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.

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

3.2 PIPING SYSTEMS - COMMON REQUIREMENTS

A. Install piping according to the following requirements and Division 23 Sections specifying piping systems.
B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

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

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

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

F. Install piping to permit valve servicing.

G. Install piping at indicated slopes.

H. Install piping free of sags and bends.

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

J. Install piping to allow application of insulation.

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

L. Install escutcheons for penetrations of walls, ceilings, and floors.

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

N. 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.

O. 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.

P. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 07 Section "Penetration Firestopping" for materials.
Q. Verify final equipment locations for roughing-in.

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

3.3 PIPING JOINT CONSTRUCTION

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

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

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

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


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

   1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
   2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

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

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

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

   1. Comply with ASTM F 402, for safe-handling practice of cleaners, primers, and solvent cements.
   2. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
   3. PVC Pressure Piping: Join schedule number ASTM D 1785, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other-than-schedule-number PVC pipe and socket fittings according to ASTM D 2855.
   4. PVC Nonpressure Piping: Join according to ASTM D 2672.

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

K. Plastic Nonpressure Piping Gasketed Joints: Join according to ASTM D 3212.

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

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

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

### 3.4 PIPING CONNECTIONS

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

1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.
2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.
3. Dry Piping Systems: Install dielectric unions and flanges to connect piping materials of dissimilar metals.

### 3.5 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 HVAC equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.

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

### 3.6 CONCRETE BASES

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

1. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit.
2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of the base.
3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to supported equipment.
6. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
7. Use 3000-psi, 28-day compressive-strength concrete and reinforcement as specified in Division 03 Section "Cast-in-Place Concrete."
3.7 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Refer to Division 05 Section "Metal Fabrications" for structural steel.

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

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

3.8 ERECTION OF WOOD SUPPORTS AND ANCHORAGES

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

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

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

3.9 GROUTING

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

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

C. Provide forms as required for placement of grout.

D. Avoid air entrapment during placement of grout.

E. Place grout, completely filling equipment bases.

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

G. Place grout around anchors.

H. Cure placed grout.

END OF SECTION 23 05 00
SECTION 23 05 13 - COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 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.

1.2 COORDINATION
A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:
   1. Motor controllers.
   2. Torque, speed, and horsepower requirements of the load.
   3. Ratings and characteristics of supply circuit and required control sequence.
   4. Ambient and environmental conditions of installation location.

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS
A. Comply with NEMA MG 1 unless otherwise indicated.

2.2 MOTOR CHARACTERISTICS
A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet above sea level.
B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.3 POLYPHASE MOTORS
A. Description: NEMA MG 1, Design B, medium induction motor.
B. Efficiency: Energy efficient, as defined in NEMA MG 1.
C. Service Factor: 1.15.
D. Multispeed Motors: Variable torque.
   1. For motors with 2:1 speed ratio, consequent pole, single winding.
2. For motors with other than 2:1 speed ratio, separate winding for each speed.


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

G. Temperature Rise: Match insulation rating.

H. Insulation: Class F.

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

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

2.4 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

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

B. Motors Used with Variable Frequency Controllers: [Ratings, characteristics, and features coordinated with and approved by controller manufacturer.]
   1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
   2. Energy- and Premium-Efficient Motors: Class B temperature rise; Class F insulation.
   3. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
   4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

2.5 SINGLE-PHASE MOTORS

A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:
   1. Permanent-split capacitor.
   2. Split phase.
   3. Capacitor start, inductor run.
   4. Capacitor start, capacitor run.

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

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

D. Motors 1/20 HP and Smaller: Shaded-pole type.
E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 23 05 13
PART 1 - GENERAL

1.1 SUMMARY
   A. Section Includes:
      1. Metal-bellows packless expansion joints.
      2. Pipe loops and swing connections.
      3. Alignment guides and anchors.

1.2 ACTION SUBMITTALS
   A. Product Data: For each type of product indicated.

1.3 INFORMATIONAL SUBMITTALS
   A. Welding certificates.
   B. Product certificates.

1.4 CLOSEOUT SUBMITTALS
   A. Maintenance data.

1.5 QUALITY ASSURANCE
   A. Welding Qualifications: Qualify procedures and personnel according to the following:
      1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
      2. ASME Boiler and Pressure Vessel Code: Section IX.

PART 2 - PRODUCTS

2.1 PACKED EXPANSION JOINTS

2.2 PACKLESS EXPANSION JOINTS
   A. Metal, Expansion-Compensator Packless Expansion Joints:
      1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Adsco Manufacturing LLC
b. Flex Pression Ltd
c. Flexicraft Industries
d. Flex-Weld, Inc
e. Hyspan Precision Products
f. Mason Industries, Inc.
g. Metraflex Company
h. Senior Flexonics Pathway
i. Unaflex
j. Unisource Manufacturing.

2. Minimum Pressure Rating: 175 psig unless otherwise indicated.

3. Configuration for Copper Tubing: Two-ply, phosphor-bronze bellows with copper pipe ends.
   a. End Connections for Copper Tubing NPS 2 and Smaller: Solder joint.
   b. End Connections for Copper Tubing NPS 2-1/2 to NPS 4: Threaded.

4. Configuration for Steel Piping: Two-ply, stainless-steel bellows; steel-pipe end connections; and carbon-steel shroud.
   a. End Connections for Steel Pipe NPS 2 and Smaller: Threaded.
   b. End Connections for Steel Pipe NPS 2-1/2 to NPS 4: Flanged.

B. Metal-Bellows Packless Expansion Joints:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Adsco Manufacturing LLC
   b. American BOA, Inc.
   c. Badger Industries, Inc.
   d. Expansion Joint Systems
e. Flex Pression Ltd
f. Flexicraft Industries
g. Flex-Weld, Inc.
h. Flo Fab Inc.
i. Hyspan Precision Products
j. Mason Industries, Inc.
k. Metraflex Company
l. Proco Products, Inc.
m. Senior Flexonics Pathway
n. Tozen Corporation
o. U.S. Bellows, Inc.
p. Unaflex
q. Unisource Manufacturing.
r. Universal Metal Hose
s. Wahlco Metroflex


3. Type: Circular, corrugated bellows with external tie rods.

4. Minimum Pressure Rating: 175 psig unless otherwise indicated.

5. Configuration: Single joint Single joint with base and double joint with base class(es) unless otherwise indicated.
   a. End Connections for Copper Tubing NPS 2 and Smaller: Solder joint.
   b. End Connections for Copper Tubing NPS 2-1/2 to NPS 4: Solder joint.
   c. End Connections for Copper Tubing NPS 5 and Larger: Flanged.

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

2.3 ALIGNMENT GUIDES AND ANCHORS

A. Alignment Guides:
   1. Description: Steel, factory-fabricated alignment guide, with bolted two-section outer cylinder and base for attaching to structure; with two-section guiding spider for bolting to pipe.

B. Anchor Materials:
   1. Steel Shapes and Plates: ASTM A 36/A 36M.
   2. Bolts and Nuts: ASME B18.10 or ASTM A 183, steel hex head.
   4. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened portland cement concrete, with tension and shear capacities appropriate for application.
   5. Chemical Fasteners: Insert-typestud, bonding-system anchor for use with hardened portland cement concrete, with tension and shear capacities appropriate for application.
      a. Bonding Material: ASTM C 881/C 881M, Type IV, Grade 3, two-component epoxy resin suitable for surface temperature of hardened concrete where fastener is to be installed.

PART 3 - EXECUTION

3.1 EXPANSION-JOINT INSTALLATION

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

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

C. Install metal-bellows expansion joints according to EJMA's "Standards of the Expansion Joint Manufacturers Association, Inc."
3.2 PIPE LOOP AND SWING CONNECTION INSTALLATION

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

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

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

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

3.3 ALIGNMENT-GUIDE AND ANCHOR INSTALLATION

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

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

C. Attach guides to pipe and secure guides to building structure.

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

E. Anchor Attachments:
   2. Anchor Attachment to Copper Tubing: Attach with pipe hangers. Use MSS SP-69, Type 24, U-bolts bolted to anchor.

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

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

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

END OF SECTION 23 05 16
SECTION 23 05 17 - SLEEVES AND SLEEVE SEALS FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Sleeves.
   2. Sleeve-seal systems.

1.2 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.1 SLEEVES

A. Cast-Iron Wall Pipes: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.

B. Galvanized-Steel Wall Pipes: ASTM A 53/A 53M, Schedule 40, with plain ends and welded steel collar; zinc coated.

C. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, with plain ends.


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

2.2 SLEEVE-SEAL SYSTEMS

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

B. Description: Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.
1. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
2. Pressure Plates: Stainless steel.
3. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements.

2.3 GROUT
B. Characteristics: Nonshrink; recommended for interior and exterior applications.
C. Design Mix: 5000-psi, 28-day compressive strength.
D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION
A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.
B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch annular clear space between piping and concrete slabs and walls.
   1. Sleeves are not required for core-drilled holes.
C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.
   1. Cut sleeves to length for mounting flush with both surfaces.
      a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level.
   2. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.
D. Install sleeves for pipes passing through interior partitions.
   1. Cut sleeves to length for mounting flush with both surfaces.
   2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
   3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Comply with requirements for sealants specified in Section 07 92 00 "Joint Sealants."
E. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Section 07 84 13 "Penetration Firestopping."
3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

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

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

3.3 SLEEVE AND SLEEVE-SEAL SCHEDULE

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

1. Exterior Concrete Walls above Grade:
   a. Piping Smaller Than NPS 6: Cast-iron wall sleeves.
   b. Piping NPS 6 and Larger: Cast-iron wall sleeves.

2. Exterior Concrete Walls below Grade:
   a. Piping Smaller Than NPS 6: Cast-iron wall sleeves with sleeve-seal system.
      1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
   b. Piping NPS 6 and Larger: Cast-iron wall sleeves with sleeve-seal system.
      1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

3. Concrete Slabs-on-Grade:
   a. Piping Smaller Than NPS 6: Cast-iron wall sleeves with sleeve-seal system.
      1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
   b. Piping NPS 6 and Larger: Cast-iron wall sleeves with sleeve-seal system.
      1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

4. Concrete Slabs above Grade:
   b. Piping NPS 6 and Larger: Galvanized-steel-pipe sleeves.

5. Interior Partitions:
SECTION 23 05 18 - ESCUTCHEONS FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY
A. Section Includes:
   1. Escutcheons.
   2. Floor plates.

1.2 ACTION SUBMITTALS
A. Product Data: For each type of product indicated.

PART 2 - PRODUCTS

2.1 ESCUTCHEONS
A. One-Piece, Cast-Brass Type: With polished, chrome-plated finish and setscrew fastener.
B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with chrome-plated finish and spring-clip fasteners.
C. One-Piece, Stamped-Steel Type: With chrome-plated finish and spring-clip fasteners.

2.2 FLOOR PLATES
A. One-Piece Floor Plates: Cast-iron flange with holes for fasteners.

PART 3 - EXECUTION

3.1 INSTALLATION
A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.
B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.
   1. Escutcheons for New Piping:
      a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
      b. Chrome-Plated Piping: One-piece, cast-brass type with polished, chrome-plated finish.
      c. Insulated Piping: One-piece, stamped-steel type.
d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished, chrome-plated finish.

e. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type.

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

g. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, stamped-steel type.

h. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass type with polished, chrome-plated finish.

i. Bare Piping in Unfinished Service Spaces: One-piece, stamped-steel type.

j. Bare Piping in Equipment Rooms: One-piece, cast-brass type with polished, chrome-plated finish.

k. Bare Piping in Equipment Rooms: One-piece, stamped-steel type.

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

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

1. New Piping: One-piece, floor-plate type.

3.2 FIELD QUALITY CONTROL

A. Replace broken and damaged escutcheons and floor plates using new materials.

END OF SECTION 23 05 18
SECTION 23 05 19 - METERS AND GAGES FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Bimetallic-actuated thermometers.
2. Liquid-in-glass thermometers.
3. Thermowells.
4. Dial-type pressure gages.
5. Gage attachments.
6. Pitot-tube flowmeters.
7. Turbine flowmeters.
8. Venturi flowmeters.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.
B. Wiring Diagrams: For power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Product certificates.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 BIMETALLIC-ACTUATED THERMOMETERS

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

1. Ashcroft Inc
2. Ernst Flow Industries
3. Marsh Bellofram
4. Miljoco Corporation
5. Nanmac Corporation
6. Noshok
7. Palmer Wahl Instrumentation
8. REOTEMP Instrument Corporation
9. Tel-Tru Manufacturing Company
10. Trerice, H.O. Corporation
11. Watts
12. Weiss Instruments, Inc.
13. Weksler Glass Thermometer
14. WIKA Instrument Corporation
15. Winters Instruments


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

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

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

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

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

H. Window: Plain glass.

I. Ring: Stainless steel.

J. Element: Bimetal coil.

K. Pointer: Dark-colored metal.

L. Accuracy: Plus or minus 1.5 percent of scale range.

2.2 LIQUID-IN-GLASS THERMOMETERS

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

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Flo Fab Inc.
   b. Miljoco Corporation
   c. Palmer Wahl Instrumentation
   d. Tel-Tru Manufacturing Company
   e. Trerice, H.O. Corporation
   f. Weiss Instruments, Inc.
   g. Weksler Glass Thermometer
   h. Winters Instruments


3. Case: Cast aluminum; 7-inch nominal size unless otherwise indicated.

4. Case Form: Adjustable angle unless otherwise indicated.

5. Tube: Glass with magnifying lens and blue or red organic liquid.

6. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F and deg C.

7. Window: Glass.
8. Stem: Aluminum and of length to suit installation.
   b. Design for Thermowell Installation: Bare stem.


10. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

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

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Ernst Flow Industries
   b. Marsh Bellofram
   c. Miljoco Corporation
   d. Palmer Wahl Instrumentation
   e. REOTEMP Instrument Corporation
   f. Watts
   g. Weiss Instruments, Inc.
   h. Weksler Glass Thermometer
   i. WIKA Instrument Corporation


3. Case: Plastic; 7-inch nominal size unless otherwise indicated.

4. Case Form: Adjustable angle unless otherwise indicated.

5. Tube: Glass with magnifying lens and blue or red organic liquid.

6. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F and deg C.

7. Window: Glass.

8. Stem: Aluminum, brass, or stainless steel and of length to suit installation.
   b. Design for Thermowell Installation: Bare stem.


10. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

2.3 DUCT-THERMOMETER MOUNTING BRACKETS

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

2.4 THERMOWELLS

A. Thermowells:


2. Description: Pressure-tight, socket-type fitting made for insertion into piping tee fitting.

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

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

2.5 PRESSURE GAGES

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

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. AMETEK, Inc
   b. Ashcroft Inc
   c. Ernst Flow Industries
   d. Flo Fab, Inc
   e. Marsh Bellofram
   f. MiJoco Corporation
   g. Noshok
   h. Palmer Wahl Instrumentation
   i. REOTEMP Instrument Corporation
   j. Tel-Tru Manufacturing Company
   k. Trerice, H.O. Corporation
   l. Watts
   m. Weiss Instruments, Inc.
   n. Weksler Glass Thermometer
   o. WIKA Instrument Corporation
   p. Winters Instruments

3. Case: Liquid-filled type(s); cast aluminum or drawn steel; 4-1/2-inch nominal diameter.
4. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
5. Pressure Connection: Brass, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
6. Movement: Mechanical, with link to pressure element and connection to pointer.
7. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi and kPa.
10. Ring: Metal, Stainless steel.
11. Accuracy: Grade B, plus or minus 2 percent of middle half of scale range.

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

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. AMETEK, Inc.
b. Ashcroft Inc.  
c. Flo Fab Inc.  
d. Marsh Bellofram  
e. Miljoco Corporation  
f. Noshok  
g. Palmer Wahl Instrumentation  
h. REOTEMP Instrument Corporation  
i. Tel-Tru Manufacturing Company  
j. Trerice, H.O. Corporation  
k. Weiss Instruments, Inc.  
l. Weksler Glass Thermometer  
m. WIKA Instrument Corporation  
n. Winters Instruments

3. Case: Sealed type; plastic; 4-1/2-inch nominal diameter.  
4. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.  
5. Pressure Connection: Brass, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.  
6. Movement: Mechanical, with link to pressure element and connection to pointer.  
7. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi and kPa.  
9. Window: Glass or plastic.  
10. Accuracy: Grade B, plus or minus 2 percent of middle half of scale range.

2.6 GAGE ATTACHMENTS  
A. Snubbers: ASME B40.100, brass; with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and piston porous-metal-type surge-dampening device. Include extension for use on insulated piping.  
B. Siphons: Loop-shaped section of stainless-steel pipe with NPS 1/4 or NPS 1/2 pipe threads.  
C. Valves: Brass or stainless-steel needle, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads.

PART 3 - EXECUTION  
3.1 INSTALLATION  
A. Install thermowells with socket extending to center of pipe and in vertical position in piping tees.  
B. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.  
C. Install thermowells with extension on insulated piping.  
D. Fill thermowells with heat-transfer medium.  
E. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.  
F. Install remote-mounted thermometer bulbs in thermowells and install cases on panels; connect cases with tubing and support tubing to prevent kinks. Use minimum tubing length.
G. Install duct-thermometer mounting brackets in walls of ducts. Attach to duct with screws.

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

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

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

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

L. Assemble and install connections, tubing, and accessories between flow-measuring elements and flowmeters according to manufacturer's written instructions.

M. Install flowmeter elements in accessible positions in piping systems.

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

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

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

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

R. Install thermometers in the following locations:

1. Inlet and outlet of each hydronic zone.
2. Inlet and outlet of each Geothermal Ground Loop.
3. Two inlets and two outlets of each chiller.
4. Inlet and outlet of each hydronic coil in air-handling units.
5. Two inlets and two outlets of each hydronic or steam heat exchanger.
6. Inlet and outlet of each thermal-storage tank.
7. Outside-, return-, supply-, and mixed-air ducts.
8. Inlet and outlet of each water to air heat pump.
9. Inlet of each steam to hot water heat exchanger.

S. Install pressure gages in the following locations:

1. Inlet and discharge of each pressure-reducing valve.
2. Inlet and outlet of each heat pump loop-water connection.
3. Suction and discharge of each pump.
4. Inlet of each steam to hot water heat exchanger.

3.2 CONNECTIONS

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

B. Connect flowmeter-system elements to meters.

C. Connect flowmeter transmitters to meters.
D. Connect thermal-energy meter transmitters to meters.

3.3 ADJUSTING

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

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

3.4 THERMOMETER SCHEDULE

A. Thermometers at inlet and outlet of each hydronic zone shall be one of the following:
   1. Sealed, bimetallic-actuated type.
   2. Industrial-style, liquid-in-glass type.

B. Thermometers at inlet and outlet of each heat pump coils, hydronic coil in air-handling units and built-up central systems shall be one of the following:
   1. Sealed, bimetallic-actuated type.
   2. Industrial-style, liquid-in-glass type.

C. Thermometers at inlets and outlets of each hydronic heat exchanger shall be one of the following:
   1. Liquid-filled, bimetallic-actuated type.
   2. Industrial-style, liquid-in-glass type.

D. Thermometers at inlet and outlet of each hydronic heat-recovery unit shall be one of the following:
   1. Liquid-filled, bimetallic-actuated type.
   2. Industrial-style, liquid-in-glass type.

E. Thermometers at inlet and outlet of each thermal-storage tank shall be one of the following:
   1. Liquid-filled, bimetallic-actuated type.
   2. Industrial-style, liquid-in-glass type.

F. Thermometers at outside-, return-, supply-, and mixed-air ducts shall be one of the following:
   1. Sealed, bimetallic-actuated type.
   2. Industrial-style, liquid-in-glass type.

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

3.5 THERMOMETER SCALE-RANGE SCHEDULE

A. Scale Range for Dry Cooler Piping: Minus 40 to plus 160 deg F.

B. Scale Range for Dry Cooler Piping: 0 to 150 deg F.

C. Scale Range for Heat Pump Loop Piping: 0 to 150 deg F.
D. Scale Range for Heating, Hot-Water Piping: 0 to 250 deg F.
E. Scale Range for Heating, Hot-Water Piping: 20 to 240 deg F.
F. Scale Range for Steam and Steam-Condensate Piping: 0 to 250 deg F.
G. Scale Range for Air Ducts: Minus 40 to plus 160 deg F.

3.6 PRESSURE-GAGE SCHEDULE
A. Pressure gages at discharge of each pressure-reducing valve shall be the following:
   1. Liquid-filled,-mounted, metal case.
B. Pressure gages at inlet and outlet of each steam heat exchanger shall be one of the following:
   1. Liquid-filled,-mounted, metal case.
C. Pressure gages at suction and discharge of each pump shall be the following:
   1. Liquid-filled,-mounted, metal case.

3.7 PRESSURE-GAGE SCALE-RANGE SCHEDULE
A. Scale Range for Condenser-Water Piping: 0 to 100 psi.
B. Scale Range for Heating, Hot-Water Piping: 0 to 100 psi.
C. Scale Range for Steam Piping: 0 to 100 psi.

3.8 THERMAL ENERGY AND FLOWMETER SCHEDULE
B. Flowmeters for Heating, Hot-Water Piping: Turbine type.
C. Flowmeters and Steam-Condensate Piping: magnetic type.

END OF SECTION 23 05 19
SECTION 23 05 23.12 - BALL VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Brass ball valves.
   2. Bronze ball valves.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of valve.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

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

B. ASME Compliance:
   1. ASME B1.20.1 for threads for threaded-end valves.
   2. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
   4. ASME B31.1 for power piping valves.
   5. ASME B31.9 for building services piping valves.

C. Bronze valves shall be made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are not permitted.

D. Refer to HVAC valve schedule articles for applications of valves.

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

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

G. Valve Actuator Types:
   1. Gear Actuator: For quarter-turn valves NPS 4 and larger.
   2. Handlever: For quarter-turn valves smaller than NPS 4.

H. Valves in Insulated Piping:
   1. Include 2-inch stem extensions.
2. Extended operating handle of nonthermal-conductive material, and protective sleeves that allow operation of valves without breaking the vapor seals or disturbing insulation.

3. Memory stops that are fully adjustable after insulation is applied.

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

### 2.2 BRASS BALL VALVES

**A. One-Piece Brass Ball Valves:**

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

2. Description:
   
b. CWP Rating: 400 psig.
c. Body Design: One piece.
d. Body Material: Forged brass.
e. Ends: Threaded.
f. Seats: PTFE.
g. Stem: Brass.
h. Ball: Chrome-plated brass.
i. Port: Reduced.

**B. Two-Piece Brass Ball Valves with Full Port and Brass Trim:**

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   
a. American Valve, Inc.
b. Conbraco Industries, Inc.
c. Crane; Crane Energy Flow Solutions.
d. DynaQuip Controls.
e. Hammond Valve.
f. Jomar Valve;
g. KITZ Corporation.
h. Legend Valve & Fitting, Inc.
i. Marwin Valve; Richards Industries.
j. Milwaukee Valve Company.
k. NIBCO INC.
l. Red-White Valve Corporation.
m. Stockham; Crane Energy Flow Solutions.
n. Watts; a Watts Water Technologies company.

2. Description:
   
b. SWP Rating: 150 psig.
c. CWP Rating: 600 psig.
d. Body Design: Two piece.
C. Two-Piece Brass Ball Valves with Full Port and Stainless-Steel Trim:

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

   a. Crane; Crane Energy Flow Solutions.
   b. Flow-Tek, Inc.
   c. Hammond Valve.
   d. Jamesbury; Metso.
   e. Jenkins Valves; Crane Energy Flow Solutions.
   f. KITZ Corporation.
   g. Marwin Valve; Richards Industries.
   h. Milwaukee Valve Company.
   i. RuB Inc.

2. Description:

   b. SWP Rating: 150 psig.
   c. CWP Rating: 600 psig.
   d. Body Design: Two piece.
   e. Body Material: Forged brass.
   f. Ends: Threaded.
   g. Seats: PTFE.
   h. Stem: Stainless steel.
   i. Ball: Stainless steel, vented.
   j. Port: Full.

D. Two-Piece Brass Ball Valves with Regular Port and Brass Trim:

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

   a. Hammond Valve
   b. Jamesbury; Metso.
   c. Legend Valve & Fitting, Inc.
   d. Marwin Valve; Richards Industries.
   e. Milwaukee Valve Company.
   f. NIBCO INC.
   g. Watts; a Watts Water Technologies company.

2. Description:

   b. SWP Rating: 150 psig.
   c. CWP Rating: 600 psig.
   d. Body Design: Two piece.
   e. Body Material: Forged brass.
f. Ends: Threaded.
g. Seats: PTFE.
h. Stem: Brass.
i. Ball: Chrome-plated brass.
j. Port: Regular.

E. Two-Piece Brass Ball Valves with Regular Port and Stainless-Steel Trim:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Jamesbury
   b. Marwin Valve

2. Description:
   b. SWP Rating: 150 psig.
   c. CWP Rating: 600 psig.
   d. Body Design: Two piece.
   e. Body Material: Brass or bronze.
   f. Ends: Threaded.
   g. Seats: PTFE.
   h. Stem: Stainless steel.
   i. Ball: Stainless steel, vented.
   j. Port: Regular.

2.3 BRONZE BALL VALVES

A. One-Piece Bronze Ball Valves with Bronze Trim:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Conbraco Industries
   b. NIBCO Inc.
   c. Watts

2. Description:
   b. CWP Rating: 400 psig.
   c. Body Design: One piece.
   d. Body Material: Bronze.
   e. Ends: Threaded.
   f. Seats: PTFE.
   g. Stem: Bronze.
   h. Ball: Chrome-plated brass.
   i. Port: Reduced.

B. One-Piece Bronze Ball Valves with Stainless-Steel Trim:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Conbraco Industries
   b. NIBCO Inc.
   c. Watts

2. Description:
   b. CWP Rating: 600 psig.
   c. Body Design: One piece.
   d. Body Material: Bronze.
   e. Ends: Threaded.
   f. Seats: PTFE.
   g. Stem: Stainless steel.
   h. Ball: Stainless steel, vented.
   i. Port: Reduced.

C. Two-Piece Bronze Ball Valves with Full Port and Bronze or Brass Trim:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. American Valve
   b. Conbraco Industries, Inc.
   c. Crane; Crane Energy Flow Solutions.
   d. Hammond Valve.
   e. Lance Valves.
   f. Legend Valve & Fitting, Inc.
   g. Milwaukee Valve Company.
   h. NIBCO INC.
   i. Red-White Valve Corporation.
   j. Watts; a Watts Water Technologies company.

2. Description:
   b. SWP Rating: 150 psig.
   c. CWP Rating: 600 psig.
   d. Body Design: Two piece.
   e. Body Material: Bronze.
   f. Ends: Threaded.
   g. Seats: PTFE.
   h. Stem: Bronze.
   i. Ball: Chrome-plated brass.
   j. Port: Full.

D. Two-Piece Bronze Ball Valves with Full Port and Stainless-Steel Trim:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Conbraco Industries, Inc.
   b. Crane; Crane Energy Flow Solutions.
c. Hammond Valve.
d. Lance Valves.
e. Milwaukee Valve Company.
f. NIBCO INC.
g. Watts; a Watts Water Technologies company

2. Description:

b. SWP Rating: 150 psig.
c. CWP Rating: 600 psig.
d. Body Design: Two piece.
e. Body Material: Bronze.
f. Ends: Threaded.
g. Seats: PTFE.
h. Stem: Stainless steel.
i. Ball: Stainless steel, vented.
j. Port: Full.

E. Two-Piece Bronze Ball Valves with Regular Port and Bronze or Brass Trim:

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

   a. American Valve
   b. Conbraco Industries, Inc.
   c. DynaQuip Controls.
   d. Hammond Valve.
   e. Jenkins Valves
   f. Lance Valves.
   g. Milwaukee Valve Company.
   h. NIBCO INC.
   i. Stockham
   j. Watts; a Watts Water Technologies company

2. Description:

   b. SWP Rating: 150 psig.
   c. CWP Rating: 600 psig.
   d. Body Design: Two piece.
   e. Body Material: Bronze.
   f. Ends: Threaded.
   g. Seats: PTFE.
   h. Stem: Bronze.
   i. Ball: Chrome-plated brass.
   j. Port: Regular.

F. Two-Piece Bronze Ball Valves with Regular Port and Stainless-Steel Trim:

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

   a. Conbraco Industries, Inc.
   b. Hammond Valve.
2. Description:
   b. SWP Rating: 150 psig.
   c. CWP Rating: 600 psig.
   d. Body Design: Two piece.
   e. Body Material: Bronze.
   f. Ends: Threaded.
   g. Seats: PTFE.
   h. Stem: Stainless steel.
   i. Ball: Stainless steel, vented.
   j. Port: Regular.

PART 3 - EXECUTION

3.1 VALVE INSTALLATION
   A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
   B. Locate valves for easy access and provide separate support where necessary.
   C. Install valves in horizontal piping with stem at or above center of pipe.
   D. Install valves in position to allow full stem movement.

3.2 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS
   A. If valves with specified SWP classes or CWP ratings are unavailable, the same types of valves with higher SWP classes or CWP ratings may be substituted.
   B. Select valves with the following end connections:
      1. For Copper Tubing, NPS 2 and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules below.
      2. For Steel Piping, NPS 2 and Smaller: Threaded ends.

3.3 HEAT PUMP LOOP VALVE SCHEDULE
   A. Pipe NPS 2 and Smaller: Two piece, full port, brass or bronze with stainless-steel trim.
      1. Valves may be provided with solder-joint ends instead of threaded ends.
3.4 HEATING-WATER VALVE SCHEDULE
   A. Pipe NPS 2 and Smaller: Two piece, full port, brass or bronze with stainless-steel trim.
      1. Valves may be provided with solder-joint ends instead of threaded ends.

3.5 LOW-PRESSURE STEAM VALVE SCHEDULE (15 PSIG OR LESS)
   A. Pipe NPS 2 and Smaller: Two piece, full port, brass or bronze with stainless-steel trim.

3.6 HIGH-PRESSURE STEAM VALVE SCHEDULE (MORE THAN 15 PSIG)
   A. Pipe NPS 2 and Smaller: One piece, full port, brass or bronze with stainless-steel trim.

3.7 STEAM-CONDENSATE VALVE SCHEDULE
   A. Pipe NPS 2 and Smaller: Two piece, full port, brass or bronze with stainless-steel trim.

END OF SECTION 23 05 23.12
SECTION 23 05 23.14 - CHECK VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Bronze lift check valves.
   2. Bronze swing check valves.
   3. Iron swing check valves.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of valve.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

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

B. ASME Compliance:
   1. ASME B1.20.1 for threads for threaded-end valves.
   2. ASME B16.1 for flanges on iron valves.
   3. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
   4. ASME B16.18 for solder joint.
   5. ASME B31.1 for power piping valves.
   6. ASME B31.9 for building services piping valves.

C. Bronze valves shall be made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are not permitted.

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

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

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

2.2 BRONZE SWING CHECK VALVES

A. Class 125, Bronze Swing Check Valves with Bronze Disc:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
CHECK VALVES FOR HVAC PIPING

2. Description:

a. Standard: MSS SP-80, Type 3.
b. CWP Rating: 200 psig.
c. Body Design: Horizontal flow.
e. Ends: Threaded.
f. Disc: Bronze.

B. Class 125, Bronze Swing Check Valves with Nonmetallic Disc:

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

a. Crane
b. Hammond Valve
c. Jenkins Valves
d. KITZ Corporation
e. Milwaukee Valve Company
f. NIBCO Inc.
g. Red-White Valve Corp.
h. Stockham
i. Watts

2. Description:

a. Standard: MSS SP-80, Type 4.
b. CWP Rating: 200 psig.
c. Body Design: Horizontal flow.
e. Ends: Threaded.
f. Disc: PTFE.

C. Class 150, Bronze Swing Check Valves with Bronze Disc:

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

a. American Valve, Inc.
b. Crane
c. Jenkins Valves
d. KITZ Corporation
e. Macomb Groups
f. Milwaukee Valve Company
g. NIBCO Inc.
h. Red-White Valve Corp.
i. Stockham

2. Description:

a. Standard: MSS SP-80, Type 3.
b. CWP Rating: 300 psig.
c. Body Design: Horizontal flow.
e. Ends: Threaded.
f. Disc: Bronze.

D. Class 150, Bronze Swing Check Valves with Nonmetallic Disc:

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

a. Crane
b. Hammond Valve
c. Jenkins Valves
d. Milwaukee Valve Company
e. NIBCO Inc.
f. Watts

2. Description:

a. Standard: MSS SP-80, Type 4.
b. CWP Rating: 300 psig.
c. Body Design: Horizontal flow.
e. Ends: Threaded.
f. Disc: PTFE.

2.3 IRON SWING CHECK VALVES

A. Class 125, Iron Swing Check Valves with Metal Seats:

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

a. Crane
b. Hammond Valve
c. Jenkins Valves
d. KITZ Corporation
e. Legend Valve & Fitting
f. Macomb Groups
g. Milwaukee Valve Company
h. NIBCO Inc.
i. Powell Valves
2. Description:
   a. Standard: MSS SP-71, Type I.
   b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
   c. NPS 14 to NPS 24, CWP Rating: 150 psig.
   d. Body Design: Clear or full waterway.
   e. Body Material: ASTM A 126, gray iron with bolted bonnet.
   f. Ends: Flanged.
   g. Trim: Bronze.
   h. Gasket: Asbestos free.

B. Class 125, Iron Swing Check Valves with Nonmetallic-to-Metal Seats:

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

2. Description:
   a. Standard: MSS SP-71, Type I.
   b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
   c. NPS 14 to NPS 24, CWP Rating: 150 psig.
   d. Body Design: Clear or full waterway.
   e. Body Material: ASTM A 126, gray iron with bolted bonnet.
   f. Ends: Flanged.
   g. Trim: Composition.
   h. Seat Ring: Bronze.
   i. Disc Holder: Bronze.
   j. Disc: PTFE.
   k. Gasket: Asbestos free.

C. Class 250, Iron Swing Check Valves with Metal Seats:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Crane
   b. Hammond Valve
   c. Jenkins Valves
   d. Milwaukee Valve Company
   e. NIBCO Inc.
   f. Stockham
   g. Watts

2. Description:
   a. Standard: MSS SP-71, Type I.
b. NPS 2-1/2 to NPS 12, CWP Rating: 500 psig.
c. NPS 14 to NPS 24, CWP Rating: 300 psig.
d. Body Design: Clear or full waterway.
e. Body Material: ASTM A 126, gray iron with bolted bonnet.
f. Ends: Flanged.
g. Trim: Bronze.
h. Gasket: Asbestos free.

2.4 IRON SWING CHECK VALVES WITH CLOSURE CONTROL

A. Class 125, Iron Swing Check Valves with Lever- and Spring-Closure Control:

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

   a. NIBCO Inc.

2. Description:

   a. Standard: MSS SP-71, Type I.
   b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
   c. NPS 14 to NPS 24, CWP Rating: 150 psig.
   d. Body Design: Clear or full waterway.
   e. Body Material: ASTM A 126, gray iron with bolted bonnet.
   f. Ends: Flanged.
   g. Trim: Bronze.
   h. Gasket: Asbestos free.
   i. Closure Control: Factory-installed, exterior lever and spring.

B. Class 125, Iron Swing Check Valves with Lever and Weight-Closure Control:

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

   a. Crane
   b. Hammond Valve
   c. Jenkins Valves
   d. Milwaukee Valve Company
   e. NIBCO Inc.
   f. Stockham
   g. Watts

2. Description:

   a. Standard: MSS SP-71, Type I.
   b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
   c. NPS 14 to NPS 24, CWP Rating: 150 psig.
   d. Body Design: Clear or full waterway.
   e. Body Material: ASTM A 126, gray iron with bolted bonnet.
   f. Ends: Flanged.
   g. Trim: Bronze.
   h. Gasket: Asbestos free.
   i. Closure Control: Factory-installed, exterior lever and weight.
PART 3 - EXECUTION

3.1 VALVE INSTALLATION

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

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

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

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

E. Install swing check valves for proper direction of flow in horizontal position with hinge pin level.

3.2 ADJUSTING

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

3.3 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. If valve applications are not indicated, use the following:

1. Pump-Discharge Check Valves:
   a. NPS 2 and Smaller: Bronze swing check valves with bronze disc.
   b. NPS 2-1/2 and Larger: Iron swing check valves with lever and weight or with spring; metal or resilient-seat check valves.

B. If valves with specified SWP classes or CWP ratings are unavailable, the same types of valves with higher SWP classes or CWP ratings may be substituted.

C. Select valves, except wafer types, with the following end connections:

1. For Copper Tubing, NPS 2 and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules.
2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules.
3. For Copper Tubing, NPS 5 and Larger: Flanged ends.
4. For Steel Piping, NPS 2 and Smaller: Threaded ends.
5. For Steel Piping, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules.
6. For Steel Piping, NPS 5 and Larger: Flanged ends.

3.4 HEAT PUMP LOOP VALVE SCHEDULE

A. Pipe NPS 2 and Smaller:

1. Bronze Valves: May be provided with solder-joint ends instead of threaded ends.
2. Bronze Swing Check Valves: Class 125, bronze disc.

B. Pipe NPS 2-1/2 and Larger:

1. Iron Valves, NPS 2-1/2 to NPS 4: May be provided with threaded ends instead of flanged ends.
2. Iron Swing Check Valves: Class 125, metal seats.
3. Iron Swing Check Valves with Closure Control, NPS 2-1/2 to NPS 12: Class 125, lever and spring.

3.5 HEATING-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller:

1. Bronze Valves: May be provided with solder-joint ends instead of threaded ends.
2. Bronze Swing Check Valves: Class 125, bronze disc.

B. Pipe NPS 2-1/2 and Larger:

1. Iron Valves, NPS 2-1/2 to NPS 4: May be provided with threaded ends instead of flanged ends.
2. Iron Swing Check Valves: Class 125, metal seats.
3. Iron Swing Check Valves with Closure Control, NPS 2-1/2 to NPS 12: Class 125, lever and spring.

3.6 LOW-PRESSURE STEAM VALVE SCHEDULE (15 PSIG OR LESS)

A. Pipe NPS 2 and Smaller:

1. Bronze Swing Check Valves: Class 125, bronze disc.

B. Pipe NPS 2-1/2 and Larger:

1. Iron Valves, NPS 2-1/2 to NPS 4: May be provided with threaded ends instead of flanged ends.
2. Iron Swing Check Valves: Class 125, metal seats.
3. Iron Swing Check Valves with Closure Control, NPS 2-1/2 to NPS 12: Class 125, lever and spring.

3.7 HIGH-PRESSURE STEAM VALVE SCHEDULE (MORE THAN 15 PSIG)

A. Pipe NPS 2 and Smaller:

1. Bronze Swing Check Valves: Class 125, bronze disc.

B. Pipe Sizes NPS 2-1/2 and Larger:

1. Iron Valves, NPS 2-1/2 to NPS 4: May be provided with threaded ends instead of flanged ends.
2. Iron Swing Check Valves: Class 125, metal seats.
3. Iron Swing Check Valves with Closure Control, NPS 2-1/2 to NPS 12: Class 125, lever and spring.
3.8 STEAM-CONDENSATE VALVE SCHEDULE

A. Pipe NPS 2 and Smaller:
   1. Bronze Swing Check Valves: Class 125, bronze disc.

B. Pipe NPS 2-1/2 and Larger:
   1. Iron Valves, NPS 2-1/2 to NPS 4: May be provided with threaded ends instead of flanged ends.
   2. Iron Swing Check Valves: Class 125, metal seats.
   3. Iron Swing Check Valves with Closure Control: Class 125, lever and spring.

END OF SECTION 23 05 23.14
SECTION 23 05 23.15 - GATE VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Bronze gate valves.
   2. Iron gate valves.
   3. Chainwheels.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of valve.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

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

B. ASME Compliance:
   1. ASME B1.20.1 for threads for threaded-end valves.
   2. ASME B16.1 for flanges on iron valves.
   3. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
   4. ASME B16.18 for solder joint.
   5. ASME B31.1 for power piping valves.
   6. ASME B31.9 for building services piping valves.

C. Bronze valves shall be made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are not permitted.

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

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

F. RS Valves in Insulated Piping: With 2-inch stem extensions.

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

2.2 BRONZE GATE VALVES

A. Class 125, NRS, Bronze Gate Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. American Valve, Inc.
   b. Crane; Crane Energy Flow Solutions.
   c. Hammond Valve.
   d. Jenkins Valves; Crane Energy Flow Solutions.
   e. Jomar Valve
   f. KITZ Corporation.
   g. Macomb Groups (The).
   h. Milwaukee Valve Company.
   i. NIBCO INC.
   j. Powell Valves.
   k. Red-White Valve Corporation.
   l. Stockham; Crane Energy Flow Solutions.
   m. Watts; a Watts Water Technologies company.

2. Description:
   a. Standard: MSS SP-80, Type 1.
   b. CWP Rating: 200 psig.
   d. Ends: Threaded or solder joint.
   e. Stem: Bronze.
   f. Disc: Solid wedge; bronze.
   g. Packing: Asbestos free.
   h. Handwheel: Malleable iron, bronze, or aluminum.

B. Class 125, RS, Bronze Gate Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. American Valve, Inc.
   b. Crane; Crane Energy Flow Solutions.
   c. Hammond Valve.
   d. Jenkins Valves; Crane Energy Flow Solutions.
   e. KITZ Corporation.
   f. Macomb Groups (The).
   g. Milwaukee Valve Company.
   h. NIBCO INC.
   i. Powell Valves.
   j. Stockham; Crane Energy Flow Solutions.
   k. Watts; a Watts Water Technologies company.

2. Description:
   a. Standard: MSS SP-80, Type 2.
   b. CWP Rating: 200 psig.
   d. Ends: Threaded or solder joint.
   e. Stem: Bronze.
   f. Disc: Solid wedge; bronze.
   g. Packing: Asbestos free.
   h. Handwheel: Malleable iron, bronze, or aluminum.
C. Class 150, NRS, Bronze Gate Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Hammond Valve
   b. KITZ Corporation
   c. Milwaukee Valve Company
   d. NIBCO Inc.
   e. Powell Valves
   f. Red-White Valve Corporation
   g. Watts

2. Description:
   a. Standard: MSS SP-80, Type 1.
   b. CWP Rating: 300 psig.
   d. Ends: Threaded.
   e. Stem: Bronze.
   f. Disc: Solid wedge; bronze.
   g. Packing: Asbestos free.
   h. Handwheel: Malleable iron, bronze, or aluminum.

D. Class 150, RS, Bronze Gate Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Crane
   b. Hammond Valve
   c. KITZ Corporation
   d. Macomb
   e. Milwaukee Valve Company
   f. NIBCO Inc.
   g. Powell Valves
   h. Stockham
   i. Watts

2. Description:
   a. Standard: MSS SP-80, Type 2.
   b. CWP Rating: 300 psig.
   d. Ends: Threaded.
   e. Stem: Bronze.
   f. Disc: Solid wedge; bronze.
   g. Packing: Asbestos free.
   h. Handwheel: Malleable iron, bronze, or aluminum.

2.3 IRON GATE VALVES

A. Class 125, NRS, Iron Gate Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Crane; Crane Energy Flow Solutions.
   b. Flo Fab Inc.
   c. Hammond Valve.
   d. Jenkins Valves; Crane Energy Flow Solutions.
   e. KITZ Corporation.
   f. Legend Valve & Fitting, Inc.
   g. Macomb Groups (The).
   h. Milwaukee Valve Company.
   i. NIBCO INC.
   j. Powell Valves.
   k. Red-White Valve Corporation.
   l. Stockham; Crane Energy Flow Solutions.
   m. Watts; a Watts Water Technologies company.

2. Description:
   a. Standard: MSS SP-70, Type I.
   b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
   c. NPS 14 to NPS 24, CWP Rating: 150 psig.
   d. Body Material: ASTM A 126, gray iron with bolted bonnet.
   e. Ends: Flanged.
   f. Trim: Bronze.
   g. Disc: Solid wedge.
   h. Packing and Gasket: Asbestos free.

B. Class 125, OS&Y, Iron Gate Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Crane
   b. Flo Fab Inc.
   c. Hammond Valve
   d. Jenkins Valves
   e. KITZ Corporation
   f. Legend Valve & Fitting
   g. Macomb
   h. Milwaukee Valve Company
   i. NIBCO Inc.
   j. Powell Valves
   k. Red-White Valve Corporation
   l. Stockham
   m. Watts

2. Description:
   a. Standard: MSS SP-70, Type I.
   b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
   c. NPS 14 to NPS 24, CWP Rating: 150 psig.
   d. Body Material: ASTM A 126, gray iron with bolted bonnet.
   e. Ends: Flanged.
   f. Trim: Bronze.
g. Disc: Solid wedge.
h. Packing and Gasket: Asbestos free.

C. Class 250, NRS, Iron Gate Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Crane
   b. NIBCO Inc.
   c. Stockham

2. Description:
   a. Standard: MSS SP-70, Type I.
   b. NPS 2-1/2 to NPS 12, CWP Rating: 500 psig.
   c. NPS 14 to NPS 24, CWP Rating: 300 psig.
   d. Body Material: ASTM A 126, gray iron with bolted bonnet.
   e. Ends: Flanged.
   f. Trim: Bronze.
   g. Disc: Solid wedge.
   h. Packing and Gasket: Asbestos free.

D. Class 250, OS&Y, Iron Gate Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Crane
   b. Hammond Valve
   c. Milwaukee Valve Company
   d. NIBCO Inc.
   e. Powell Valves
   f. Stockham
   g. Watts

2. Description:
   a. Standard: MSS SP-70, Type I.
   b. NPS 2-1/2 to NPS 12, CWP Rating: 500 psig.
   c. NPS 14 to NPS 24, CWP Rating: 300 psig.
   d. Body Material: ASTM A 126, gray iron with bolted bonnet.
   e. Ends: Flanged.
   f. Trim: Bronze.
   g. Disc: Solid wedge.
   h. Packing and Gasket: Asbestos free.

2.4 CHAINWHEELS

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

1. Babbitt Steam specialty
2. Roto Hammer Industries
3. Trumbull Industries

B. Description: Valve actuation assembly with sprocket rim, chain guides, chain, and attachment brackets for mounting chainwheels directly to hand wheels.

1. Sprocket Rim with Chain Guides: Ductile iron, of type and size required for valve.
2. Chain: Hot-dip-galvanized steel, of size required to fit sprocket rim.

PART 3 - EXECUTION

3.1 VALVE INSTALLATION

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

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

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

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

E. Install chainwheels on operators for gate valves NPS 4 and larger and more than 96 inches above floor. Extend chains to 60 inches above finished floor.

3.2 ADJUSTING

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

3.3 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. If valve applications are not indicated, use the following:

1. Shutoff Service: Gate valves.

B. If valves with specified SWP classes or CWP ratings are unavailable, the same types of valves with higher SWP classes or CWP ratings may be substituted.

C. Select valves, except wafer types, with the following end connections:

1. For Copper Tubing, NPS 2 and Smaller: Threaded ends, except where solder-joint valve-end option is indicated in valve schedules below.
2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flanged ends, except where threaded valve-end option is indicated in valve schedules below.
3. For Copper Tubing, NPS 5 and Larger: Flanged ends.
4. For Steel Piping, NPS 2 and Smaller: Threaded ends.
5. For Steel Piping, NPS 2-1/2 to NPS 4: Flanged ends, except where threaded valve-end option is indicated in valve schedules below.
6. For Steel Piping, NPS 5 and Larger: Flanged ends.
3.4 LOW-PRESSURE STEAM VALVE SCHEDULE (15 PSIG OR LESS)
   A. Pipe NPS 2 and Smaller: Bronze Gate Valves, Class 125, RS.
   B. Pipe NPS 2-1/2 and Larger: Iron Gate Valves, Class 125, OS&Y.

3.5 HIGH-PRESSURE STEAM VALVE SCHEDULE (MORE THAN 15 PSIG)
   A. Pipe NPS 2 and Smaller: Bronze Gate Valves, Class 125, RS, bronze.
   B. Pipe NPS 2-1/2 and Larger: Iron Gate Valves, Class 125, OS&Y.

3.6 STEAM-CONDENSATE VALVE SCHEDULE
   A. Pipe NPS 2 and Smaller: Bronze Gate Valves, Class 125, RS.
   B. Pipe NPS 2-1/2 and Larger: Iron Gate Valves, Class 125, OS&Y.

END OF SECTION 23 05 23.15
PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Metal pipe hangers and supports.
2. Trapeze pipe hangers.
3. Thermal-hanger shield inserts.
4. Fastener systems.
5. Equipment supports.

1.2 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design trapeze pipe hangers and equipment supports, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

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

1. Design supports for multiple pipes capable of supporting combined weight of supported systems, system contents, and test water.
2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
3. Design seismic-restraint hangers and supports for piping and equipment.

1.3 ACTION SUBMITTALS

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

B. Shop Drawings: Show fabrication and installation details and include calculations for the following; include Product Data for components:

1. Trapeze pipe hangers.
2. Equipment supports.

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

1.4 INFORMATIONAL SUBMITTALS

A. Welding certificates.
1.5 QUALITY ASSURANCE

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

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

PART 2 - PRODUCTS

2.1 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:
   1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
   2. Galvanized Metallic Coatings: Pregalvanized or hot dipped.
   3. Nonmetallic Coatings: Plastic coating, jacket, or liner.
   4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.

B. Stainless-Steel Pipe Hangers and Supports:
   1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
   2. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.

C. Copper Pipe Hangers:
   1. Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.

2.2 TRAPEZE PIPE HANGERS

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

2.3 THERMAL-HANGER SHIELD INSERTS

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

B. Insulation-Insert Material for Hot Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate with 100-psig minimum compressive strength.

C. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.
D. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.

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

2.4 FASTENER SYSTEMS

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

B. Mechanical-Expansion Anchors: Insert-wedge-type, stainless-steel anchors, for use in hardened portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

2.5 EQUIPMENT SUPPORTS

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

2.6 MISCELLANEOUS MATERIALS

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

B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.

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

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT INSTALLATION

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

B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.

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

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

D. Fastener System Installation:
1. Install 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.

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


G. 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.

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

I. 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.

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

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

L. Insulated Piping:

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

2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

4. Shield Dimensions for Pipe: Not less than the following:
   a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
   b. NPS 4: 12 inches long and 0.06 inch thick.
3.2 EQUIPMENT SUPPORTS

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

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

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

3.3 METAL FABRICATIONS

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

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

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

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

3.4 ADJUSTING

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

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

3.5 PAINTING

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

1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.
B. Touchup: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Section 09 91 23 “Interior Painting”

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

3.6 HANGER AND SUPPORT SCHEDULE

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

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

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

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

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

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

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

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

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

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

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30.
2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 deg F, pipes NPS 4 to NPS 24, requiring up to 4 inches of insulation.
3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36, requiring clamp flexibility and up to 4 inches of insulation.
4. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
5. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30.
6. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
7. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
8. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30, from two rods if longitudinal movement caused by expansion and contraction might occur.
9. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
K. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

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

L. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.

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

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.
7. 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.
8. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
9. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.

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

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

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

1. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
2. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41, roll hanger with springs.
3. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.
P. Comply with MSS SP-69 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.

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

END OF SECTION 23 05 29
PART 1 - GENERAL

1.1 SUMMARY

This Section includes the following:

1. Isolation pads.
2. Isolation mounts.
3. Restrained elastomeric isolation mounts.
4. Freestanding and restrained spring isolators.
5. Housed spring mounts.
6. Elastomeric hangers.
7. Spring hangers.
8. Spring hangers with vertical-limit stops.
9. Pipe riser resilient supports.
10. Resilient pipe guides.
11. Restraining braces and cables.

1.2 PERFORMANCE REQUIREMENTS

Seismic-Restraint Loading:

1. Soil Site Class as Defined in the IBC: D.
2. Seismic Design Category: D
3. Assigned Seismic Use Group or Building Category as Defined in the IBC: III.
   a. Component Importance Factor 1.5 shall be applied to the following systems
      1) Steam Piping and equipment.
      2) Smoke Exhaust Fans
   b. a Component Importance Factor of 1.0 shall be applied to the following systems:
      1) All components unless listed for Importance factor of 1.5.
4. Design Spectral Response Acceleration at Short Periods (0.2 Second): 0.59%.
5. Design Spectral Response Acceleration at 1-Second Period: 0.28%.

1.3 DESCRIPTION

The work in this section consists of furnishing engineering and materials necessary for vibration isolation and seismic restraints for equipment contained herein for the project.

Other sections of DIVISION 22 and 23 form a part of this section. Refer to all sections for a complete description of the work.
All mechanical equipment 0.75 HP and over listed in the equipment schedule shall be mounted on vibration isolators to prevent the transmission of objectionable vibration and vibration induced sound to the building structure.

All isolation materials, flexible connectors and seismic restraints shall be selected and certified using published or factory certified data. Any variance or non-compliance with these specification requirements shall be corrected by the contractor in an approved manner.

The contractor and manufacturer of the isolation and seismic equipment shall refer to the isolator and seismic restraint schedule which lists isolator types, isolator deflections and seismic restraint type. Vibration isolators shall be selected in accordance with the equipment, pipe or duct weight distribution so as to produce reasonably uniform deflections.

Install full line size flexible pipe connectors at the inlet and outlet of each pump, chiller, cooling connections and where shown on the drawings. All connectors shall be suitable for use at the temperature, pressure, and service encountered at the point of installation and operation. End fitting connectors shall conform to the pipefitting schedule. Control rods or protective braid must be used to limit elongation to 3/8”. Flexible connectors shall not be required for suspended in-line pumps.

Unless otherwise specified, all mechanical, electrical, and plumbing equipment, pipe, and duct shall be restrained to resist seismic forces per the IBC and ASCE 7-05. Restraints shall maintain equipment, piping, and duct work in a captive position. Restraint devices shall be designed and selected to meet the seismic requirements as defined in the latest issue of the IBC or local jurisdiction building code.

1.4 Seismic restraint is NOT required to be applied to the following:

1.5 These requirements are per the International Building Code which references ASCE 7. Contractor to obtain a copy of this document BEFORE BIDDING to ensure all requirements are understood and thereafter to keep it on the job site for reference. Herein is a summary of the seismic bracing exceptions:

Seismic Design Category B: All mechanical and electrical components

Seismic Design Category C: All mechanical and electrical components with Importance factor of Ip=1.0.

Rigidly floor mounted mechanical, electrical, and plumbing components in all seismic design categories, where \( I_p = 1.0 \) and flexible connections between the components and associated duct work, piping and conduit are provided, that are mounted at 4 feet (1219 mm) or less above a floor level and weight 400 pounds (1780 N) or less and are not critical to the continued operation of the structure. Suspended, wall mounted and flexibly mounted equipment are not included in this exclusion.

Hanging, wall mounted, and flexibly supported mechanical, plumbing and electrical components that weigh 20 pounds (89 N) or less, where \( I_p = 1.0 \) and flexible connections are provided between the components and associated duct work, piping and conduit.

Piping supported by individual clevis hangers where the distance, as measured from the top of the pipe to the supporting structure, is less than 12 inches (305mm) for the entire pipe run and the pipe can accommodate the expected deflections. Trapeze or double rod hangers where the distance from the top of the trapeze or support to the structure is less than 12 inches for the entire run. Hanger rods shall not be constructed in a manner that would subject the rod to bending moments (swivel, eye bolt, or vibration isolation hanger connection to structure.)
High deformability piping (steel, copper, aluminum with welded, brazed, ground, or screwed connections); provisions are made to avoid impact with larger piping or mechanical components or to protect piping in the event of such impact; and the following size requirements are met:

1. Seismic Class C: where Ip=1.5 and a nominal pipe size of 2” or less.
2. Seismic Class D, E, F: having an Ip=1.0 and a nominal pipe size of 3 inch or less.
3. Seismic Class D, E, F: having an Ip = 1.5 and a nominal pipe size of 1 inch (25 mm) or less where provisions are made to protect the piping from impact or to avoid the impact of larger piping or other mechanical equipment. Note, any combination of piping supported on a trapeze where the total weight exceeds 10 lb/ ft. must be braced.

PVC or other plastic or fiberglass vent piping.

HVAC ducts with an suspended from hangers that are 12 inches (305 mm) or less in length from the top of the duct to the supporting structure and the hangers are detailed to avoid significant bending of the hangers and their connections. Duct must be positively attached to hanger with minimum #10 screws within 2” from the top of the duct.

HVAC ducts that have a cross sectional area of less than 6 square feet (0.557 m2).

Equipment items installed in-line with the duct system (e.g, fans, heat exchangers and humidifiers) with an operating weight less than 76 pounds (334 N). Equipment must be rigidly attached to duct at inlet and outlet.

1.6 MANUFACTURER’S RESPONSIBILITIES: Manufacturer of vibration and seismic control products shall have the following responsibilities:

Determine vibration isolation and seismic restraint sizes and locations.

Provide piping, ductwork and equipment isolation systems and seismic restraints as scheduled or specified.

Provide installation instructions and shop drawings for all materials supplied under this section of the specifications.

Provide calculations to determine restraint loads resulting from seismic forces presented in the IBC, Chapter 16 latest edition. Seismic calculations shall be certified by a licensed engineer in the employ of the seismic equipment manufacturer with a minimum 5 years experience. Provide calculations for all floor or roof mounted equipment 400lbs (1780 N) or greater (20lbs (89 N)or greater for Ip=1.5), all suspended or wall mounted equipment 20lbs (89 N)or greater, and vibration isolated equipment 20lbs (89 N)or greater.

Seismic restraint load ratings must be certified and substantiated by testing or calculations under direct control of a registered professional engineer.

Calculations and restraint device submittal drawings shall specify anchor bolt type, embedment, concrete compressive strength, minimum spacing between anchors, and minimum distances of anchors from concrete edges. Concrete anchor locations shall not be near edges, stress joints, or an existing fracture. All bolts shall be ASTM A307 or better.

1.7 QUALITY CONTROL

The isolators and seismic restraint systems listed herein are as manufactured by Amber / Booth. Approved equals that meet the requirements of the specifications, are acceptable.
Steel components shall be cleaned and painted with industrial enamel. All nuts, bolts and washers shall be zinc-electroplated. Structural steel bases shall be thoroughly cleaned of welding slag and primed with zinc-chromate or metal etching primer.

All isolators, bases and seismic restraints exposed to the weather shall utilize cadmium-plated, epoxy coat or PVC coated springs and hot dipped galvanized steel components. Nuts, bolts and washers may be zinc-electroplated. Isolators for outdoor mounted equipment shall provide adequate restraint for the greater of either wind loads required by local codes or withstand a minimum of 30 lb. / sq. ft. applied to any exposed surface of the equipment.

Provide a written quality control procedure that outlines complete compliance of attachment of cabling restraints to brackets. For swaged connections, provide a gage to verify swage. For screw/clamp connection, provide torque values for attachment fasteners.

1.8 SUBMITTALS

Product Data: For each product indicated.

Delegated-Design Submittal: For vibration isolation and seismic-restraint calculations and details indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

Welding certificates.

Qualification Data: For professional engineer.

Field quality-control test reports.

Submit shop drawings of all isolators, seismic restraints and calculations provided.

The manufacturer of vibration isolation products shall submit the following data for each piece of isolated equipment: clearly identified equipment tag, quantity and size of vibration isolators and seismic restraints for each piece of rotating isolated equipment. Submittals for mountings and hangers incorporating springs shall include spring diameter and free height, rated deflections, and solid load. Submittals for bases shall clearly identify locations for all mountings as well as all locations for attachment points of the equipment to the mounting base. Submittals shall include seismic calculations signed and checked by a qualified licensed engineer in the employ of the manufacturer of the vibration isolators. Catalog cut sheets and installation instructions shall be included for each type of isolation mounting or seismic restraint used on equipment being isolated.

Submit quality assurance procedures as required at time of isolator/seismic submittals. Submittal must be stamped by a registered professional engineer who is responsible for the seismic restraint design. All vibration isolation/seismic submittals not complying with this certification will be rejected.

Provide shop drawings indicating location of all specification SC cable restraints required for pipe and ductwork. Drawings must be stamped by manufacturer's registered professional engineer.

Mechanical, electrical and plumbing equipment manufacturers shall provide certification that their equipment is capable of resisting expected seismic loads without failure. Equipment manufacturers shall provide suitable attachment points and/or instructions for attaching seismic restraints.

Provide a certification from the seismic design engineer that the seismic restraints will comply with the applicable code requirements. Certification must be stamped by a registered profession engineer.
Provide a Certificate of Completion from the manufacturer’s representative upon completion of the job.

PART 2 - PRODUCTS

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

1. Ace Mountings Co., Inc.
2. Amber/Booth Company, Inc.
4. Isolation Technology, Inc.
7. Vibration Eliminator Co., Inc.
8. Vibration Isolation.

2.2 VIBRATION ISOLATORS:

Specification W: a pad type mounting consisting of two layers of ribbed elastomeric pads with a ½” poro-elastic vibration absorptive material bonded between them. Pads shall be sized for approximate deflection of 0.10” to 0.18”. Pads shall be Amber/Booth Type NRC (or equal).

Specification A: an elastomeric mounting having a steel baseplate with mounting holes and a threaded insert at top of the mounting for attaching equipment. All metal parts shall be completely embedded in the elastomeric material. Mountings shall be designed for approximately 1/2” deflection, and incorporate a steel seismic snubber with all directional restraint. Mountings shall be Amber/Booth Type SRVD (or equal).

Specification B: an adjustable, freestanding, open spring mounting with combination leveling and equipment fastening bolt. The spring shall be welded to the spring mounting baseplate and compression plate for stability. The isolator shall be designed for a minimum kx/ky (horizontal-to-vertical spring rate) of 1.0. An elastomeric pad having a minimum thickness of 1/4” shall be bonded to the baseplate. Nuts, adjusting bolts and washers shall be zinc-electroplated to prevent corrosion. This type isolator must be used with specification SL seismic restraint (section 2.3.1). Isolators shall be Amber/Booth Type SW (or equal).

Specification C: a unitized adjustable, stable open spring isolator with a seismic restraint housing which serves as a blocking device during equipment installation. The spring package shall include an elastomeric pad for high frequency absorption at the base of the spring. The springs shall be designed for a minimum kx/ky (horizontal-to-vertical spring rate) of 1.0. Nuts, adjusting bolts and washers shall be zinc-electroplated to prevent corrosion. The spring assembly shall be removable with equipment in place and shall fit within a welded steel enclosure consisting of a top plate and rigid lower housing. Isolated seismic restraint bolts shall connect top plate to lower housing to resist seismic and wind forces in all directions and limit motion to a maximum of 1/4” movement before engaging. Surfaces that engage under seismic motion shall be cushioned with a resilient elastomeric pad or grommet to protect equipment. Top plate shall have adequate means for fastening to the equipment, and baseplate shall have adequate means for bolting to structure. Entire assembly shall be rated to exceed the applied seismic load (para 1.3.4.). Seismic isolator shall be Amber/Booth Type CTER (or equal).

Specification D: an elastomeric hanger consisting of a rectangular steel box capable of 200% minimum overload without visible deformation, 30 degree rod misalignment and an elastomeric isolation element designed for approximately 1/2” deflection. Hangers shall be Amber/Booth Type BRD (or equal).
Specification E: a combination spring and elastomeric hanger consisting of a rectangular steel box capable of 200% minimum overload without visible deformation, 30 degree rod misalignment, coil spring, spring retainers and elastomeric element designed for approximately 1/2" deflection. The spring shall be designed for a minimum kx/ky (horizontal-to-vertical spring rate) of 1.0. Spring hangers shall be Amber/Booth Type BSRA (or equal).

Specification F: a set (two or more) of spring thrust resisting assemblies, which consist of coil springs, spring retainer, isolation washer, angle mounting brackets, and elastomeric tubing for isolating thrust resister rod from fan discharge. Thrust restraints shall be Amber / Booth Type TRK (or equal).

Specification SB: a unitized adjustable open spring isolator and a welded steel housing designed to resist seismic forces in all directions. Restraint surfaces which engage under seismic motion shall be cushioned with a resilient elastomer to protect equipment. Restraints shall allow a maximum of 1/4” movement before engaging and shall allow for the spring to be changed if required. Isolator shall be a stable spring with a minimum ky/ky of 1.0. The spring package shall include an elastomeric pad for high frequency absorption at the base of the spring. Nuts and bolts shall be zinc-electroplated to prevent corrosion. Bolting equipment to isolator with bolts smaller than main adjusting bolt will not be allowed. Base plate shall provide means for bolting to the structure. Entire assembly shall be rated to exceed the applied seismic load (para 1.3.4.) Mountings shall be Amber/Booth Type SWSR (or equal).

2.3 BASES

Specification G: a welded integral structural steel fan and motor base with NEMA standard motor slide rails and holes drilled to receive the fan and motor slide rails. The steel members shall be adequately sized to prevent distortion and misalignment of the drive, and specifically, shall be sized to limit deflection of the beam on the drive side to 0.05” due to starting torque. Snubbers to prevent excessive motion on starting or stopping shall be furnished if required; however, the snubbers shall not be engaged under steady running conditions. Bases shall be Amber/Booth Type SFB (or equal).

Specification H: a welded WF (main member) structural steel base for increasing rigidity of equipment mounted thereon or for unitizing belt driven fans. Fan bases shall have holes drilled to match fan and located to provide required center distance between fan and supplied NEMA standard motor slide rails. The steel members shall have minimum depth of 1/12” of the longest span, but not less than 6” deep. Junior beams and junior channels shall not be used. Cross members shall be provided where necessary to support the equipment or to prevent twisting of the main members. Where height restrictions prevent the use of members having a depth of 1/12 of the longest span, beams of less depth may be used provided they have equal rigidity. Provide height-saving brackets for side mounting of the isolators. Brackets for use with Specification type B isolators having 2.5” deflection or greater shall be of the precompression type to limit exposed bolt length. Bases shall be Amber/Booth Type WSB (or equal).

Specification J: a concrete inertia base consisting of perimeter structural steel concrete pouring form (CPF), reinforcing bars welded in place, bolting templates with anchor bolts and height-saving brackets for side mounting of the isolators. Brackets for use with Specification type B isolators having 2.5” deflection or greater shall be of the pre-compression type to limit exposed bolt length. The perimeter steel members shall have a minimum depth of 1/12 of the longest span, but not less than 6” deep. The base shall be sized with a minimum overlap of 4” around the base of the equipment and, in the case of belt-driven equipment, 4” beyond the end of the drive shaft. Fan bases are to be supplied with NEMA standard motor slide rails. The bases for pumps shall be sized to support the suction elbow of end suction pumps and both the suction and discharge elbows of horizontal split-case pumps. The bases shall be T-shaped where necessary to conserve space. Inertia bases shall be Amber/Booth Type CPF (or equal).
2.4 SEISMIC RESTRAINTS:

Specification SL: a restraint assembly for floor mounted equipment consisting of welded steel interlocking assemblies welded or bolted securely to the equipment or the equipment bases and to the supporting structure. Restraint assembly surfaces which engage under seismic motion shall be lined with a minimum ¼” thick resilient elastomeric pad to protect equipment. Restraints shall be field adjustable and be positioned for 1/4” clearance as required to prevent interference during normal operation. Restraint assembly shall have minimum rating of 2 times the catalog rating at 1 G as certified by independent laboratory test. Restraint shall be Amber/Booth Type ER (or equal).

Specification SC: a restraint assembly for suspended equipment, piping or ductwork consisting of high strength galvanized steel aircraft cable. Cable must have Underwriters Laboratories listed certified break strength, and shall be color-coded for easy field verification. Secure cable to structure and to braced component through bracket or stake eye specifically designed to exceed cable restraint rated capacity. Cable must be manufactured to meet or exceed minimum materials and standard requirements per AISI Manual for structural applications of steel cables and ASTM A603. Break strengths must be per ASTM E-8 procedures. Safety factor of 1.5 may be used when prestretched cable is used with end connections designed to meet the cable break strength. Otherwise safety factor 3.76 must be used. Cables shall be sized for a force as listed in section 1.3. Cables shall be installed to prevent excessive seismic motion and so arranged that they do not engage during normal operation. Restraint shall be type LRC (or equal).

2.5 ROOFTOP UNIT CURBS AND ISOLATION SYSTEMS

Specification W: Non-isolated seismically rated rooftop curb system that is flashed into roofing membrane. Air and watertight curb shall have a neoprene sponge seal at the top and be rigid enough provide continuous perimeter support for rooftop unit. Curb must provide means to positively anchor to concrete deck, or bolt or weld directly to structural steel to withstand seismic loading. Curb shall provide a means by which contractor supplied insulation may be installed for thermal insulation and acoustic attenuation. Curbs shall accommodate roof pitch shown on drawings. Curb shall use minimum 16 gage galvanized steel and shall be designed with crossbracing required to withstand the greater of seismic forces (para 1.3.4.) or wind loading per local building code. Design must be certified by registered professional engineer in the employ of the manufacturer. Seismic curbs shall be Amber/Booth Type RTC (or equal).

Specification X: An extruded aluminum rail base for roof top air conditioning units consisting of top and bottom weatherproofed aluminum rails for mounting between equipment and roof curb, incorporating wind/seismic restraints and a continuous air and water seal which is protected from accidental puncture and direct sunlight by an aluminum weather shield. Rails shall incorporate free standing, open spring isolators (minimum kx/ky of 1.0) properly spaced and sized around perimeter for the deflection listed in the isolation schedule. To prevent leaks, rails shall be factory assembled (to the limits of freight carriers) and shipped as a one-piece unit. Where spliced, corners to be factory assembled. Specification X rails may only be used where wind/seismic restraint are capable of withstanding seismic forces per paragraph 1.3.4. Seismic design of the curb supporting the isolation rail shall be provided by the roof curb manufacturer. Rails shall be Amber/Booth Type RTIR (or equal).

Specification Y: Seismically rated rooftop isolation curb system that is flashed into roofing membrane. Standard unit curb will not be used. Air and watertight upper curb shall have a neoprene sponge seal at the top and be rigid enough provide continuous perimeter support for rooftop unit. The upper curb shall be supported by type C isolators welded or bolted to continuous structural support which is positively anchored to concrete deck or bolted or welded to the structure to withstand seismic loading. An EPDM nylon reinforced airtight weatherproof seal shall consolidate the upper and lower curbs. Weatherproof access doors shall be provided at each isolator to allow isolator adjustment. Isolation curb shall provide a means by which contractor supplied insulation may be installed for thermal insulation and acoustic attenuation. Curbs shall accommodate roof pitch shown on drawings. Isolation curb shall use minimum 16 gage galvanized steel and shall be designed with crossbracing required to withstand the greater of seismic forces (para 1.3.4,) or wind loading per local building code. Design must be
certified by registered professional engineer in the employ of the manufacturer. Isolation curbs shall be Amber/Booth Type RTIC (or equal).

2.6 FLEXIBLE PIPE CONNECTIONS

Specification K:

1. Water Service: For flanged connection – a double sphere arch rubber expansion joint constructed of molded reinforced neoprene with integral steel floating flanges, and designed to be suitable for pressures up to 225 PSI (4 to 1 safety factor) and temperatures up to 225 °F. Connectors shall have minimum movement capabilities of 1.77” compression, 1.18” lateral and 1.18” extension. Connectors shall provide a minimum 35° angular movement up to 6”, minimum 30° up to 12” and minimum 20” up to 24”. Spring-loaded control units shall be furnished to limit movement to within allowables. Amber/Booth Type 2600 (or equal).

2. Water Service: For threaded type – A double spherical rubber hose connector, minimum 8” long, constructed of molded neoprene, nylon cord reinforced, with female pipe unions each end. Connectors shall have a minimum movement capability of 7/8” compression, 7/8” lateral, 1/4” extension and 20” angular through 1-1/4”, 13° through 2”, and 9° through 3”. Connectors shall be suitable for a maximum working pressure (4 to 1 safety factor) of 150 psi and 225 degree F. Connectors shall have cable control units to limit extension to 1/4”. Amber/Booth Type 2655 (or equal).

Specification L: Steam and Condensate Service:

3. For flanged connection – a metal hose connector constructed of stainless steel hose and braid with carbon steel plate flanges. Live lengths shall conform to hose minimum length to absorb thermal and dynamic movement. Hose axis must be perpendicular to pipe movement. Amber/Booth Type SS-FP or SS-FW (or equal).

4. For threaded connections - a metal hose connector constructed of stainless steel hose and braid with carbon steel NPT threaded end fittings. Minimum lengths shall conform to the following (Amber/Booth Type SS-PM (or equal).

a. 1-1/2” dia. (and smaller) x 10” long
b. 2” x 12”
c. 2-1/2” x 13”
d. 3” x 14”
e. 3-1/2” x 16”
f. 4” x 16”

Air Compressor Service

5. For flanged connection – a flanged metal hose connector constructed of stainless steel hose and braid with carbon steel plate flanges. Connector shall be double braided with a minimum live length equal to four times the diameter. Connector shall be installed with the long axis perpendicular to the motion to be absorbed. Amber/Booth Type SS-FP (Special) (or equal).

6. For threaded connection – a metal hose connector constructed of stainless steel hose and braid with carbon steel NPT threaded end fittings. Connector shall be double braided and have a minimum live length equal to four times the diameter. Connector shall be installed with the long axis perpendicular to the motion to be absorbed. Amber/Booth Type SS-PM (special) (or equal).
2.7 PIPE GUIDES AND ANCHORS FOR ISOLATED PIPING

Specification M: For Pipe Guides where specifically shown on drawings to accommodate expansion loops and compensators, the vibration isolator manufacturer shall provide pipe guides consisting of a telescopic arrangement of two sizes of steel tubing separated by a minimum, half inch thickness of heavy duty neoprene and duck or elastomeric isolation material. Guides shall be Amber/Booth type AG (or equal).

Specification N: For anchors where specifically shown on drawings to accommodate expansion loops and compensators, the vibration isolator manufacturer shall provide all directional acoustical pipe anchors consisting of a telescopic arrangement of two sizes of steel tubing separated by a minimum half inch thickness of heavy duty neoprene and duck or elastomeric isolation material. All-directional anchors shall be Amber/Booth type AG (or equal).

PART 3 - EXECUTION

3.1 Isolator and seismic restraints shall be installed as recommended by the manufacturer. Isolate all mechanical equipment 0.75 hp and over per the isolation schedule and these specifications.

3.2 PIPING ISOLATION

Horizontal Pipe Isolation: all HVAC pumped water, pumped condensate, glycol, and refrigerant piping size 1-1/4” and larger within mechanical rooms shall be isolated. Outside equipment rooms this piping shall be isolated for the greater of 50’ or 100 pipe diameters from rotating equipment. For the first 3 support locations from externally isolated equipment provide specification E hangers or specification SB or SX floor mounts with the same deflection as equipment isolators (max 2”). All other piping within the equipment rooms shall be isolated with the same specification isolators with a 3/4” minimum deflection. Steam piping size 1-1/4” and larger which is within an equipment room and connected to rotating equipment shall be isolated for three (3) support locations from the equipment. Provide specification E or SB (SX) isolators with the same deflection as the equipment but a minimum of 3/4”.

All plumbing pumped water, pumped condensate, and steam piping size 1-1/4” and larger within mechanical rooms shall be isolated the same as HVAC piping (para. 3.2-A). Isolators are not required for any plumbing pumped water, pumped condensate, and steam piping outside of mechanical rooms unless listed in the isolation schedule.

Pipe Riser Isolation: All variable temperature vertical pipe risers 1-1/4” and larger, riser piping requiring isolation per para. 3.2-A or 3.2-B or where specifically shown and detailed on riser drawings shall be fully supported by specification B mounts with precompression plates. Steel spring deflection shall be 3/4-inch minimum except in those locations where added deflection is required due to pipe expansion and contraction. Spring deflection shall be a minimum of 4 times the anticipated deflection change. Springs shall be selected to keep the riser in tension. Pipe risers up through 16” shall be supported at intervals of every third floor of the building. Pipe risers 18” and over, every second floor. Wall sleeves for take-offs from riser shall be sized for insulation O.D. plus two times the anticipated movement to prevent binding. Horizontal take-offs and at upper and lower elbows shall be supported with spring isolators as required to accommodate anticipated movement. In addition to submittal data requirements previously outlined, riser diagrams and calculations shall be submitted for approval. Calculations must show anticipated expansion and contraction at each support point, initial and final loads on the building structure, and spring deflection changes. Submittal data shall include certification that the riser system has been examined for excessive stresses and that none will exist if installed per design proposed. Riser supports shall be Amber/Booth Type SWP.
3.3 **DUCT ISOLATION:**

Isolate all duct work with a static pressure 2" W.C. and over in equipment rooms and to minimum of 50 feet from the fan or air handler. Use specification type E hangers or type SB (SX) floor mounts.

3.4 **INSTALLATION**

Comply with manufacturer’s instructions for the installation and load application of vibration isolation materials and products. Adjust to ensure that units do not exceed rated operating deflections or bottom out under loading, and are not short-circuited by other contacts or bearing points. Remove space blocks and similar devices (if any) intended for temporary support during installation or shipping.

Locate isolation hangers as near the overhead support structure as possible.

Adjust leveling devices as required to distribute loading uniformly on isolators. Shim units as required where leveling devices cannot be used to distribute loading properly.

Install isolated inertia base frames and steel bases on isolator units as indicated so that a minimum of 2 inch clearance below base will result when supported equipment has been installed and loaded for operation.

Roof curbs shall be installed directly to building structural steel or concrete roof deck. Installation on top of steel deck or roofing material is not acceptable.

3.5 **APPLICATION OF SEISMIC RESTRAINTS**

**ISOLATED EQUIPMENT**

1. All floor mounted isolated equipment shall be protected with type SB or type C unitized isolator and restraint or with separate type SL restraints (minimum of 4) in conjunction with type B isolators. For equipment with high center of gravity additional cable restraints shall be furnished, as required by isolation manufacturer, to limit forces and motion caused by rocking.

2. All suspended isolated equipment and vessels shall be protected with specification SC restraints. Cables shall be installed to prevent excessive seismic motion and so arranged that they do not engage during normal operation.

**RIGIDLY MOUNTED EQUIPMENT**

3. Floor mounted which are not exempt shall be protected by properly sized anchor bolts with elastomeric grommets provided by the isolation manufacturer. Suspended equipment shall be protected with type SC bracing.

**PIPING**

4. All piping shall be protected in all planes by SC restraints, designed to accommodate thermal movement as well as restrain seismic motion. (Spring-loaded control rods should be used on flexible connectors in system). Tanks and vessels connected inline to piping shall be restrained independently. Locations shall be as determined by the isolator/seismic restraint supplier and shall include, but not be limited to:

a. At a proximity to protect all drops to equipment connections.

b. At changes in direction of pipe as required to limit over stressing of pipe or movement that contacts other building material.
c. At horizontal runs of pipe, not to exceed the spacing as presented in SMACNA design criteria.
d. SMACNA design criteria. Seismic restraints shall not be required for piping exempted by previous specification sections.
e. Where riser pipes pass through cored holes, core diameters to be a maximum of 2” larger than pipe O.D. including insulation. Cored holes must be packed with resilient material or firestop as provided by other sections of this specification or local codes. No additional horizontal seismic bracing is required. Restrained isolators type C or SB shall support risers and provide longitudinal restraint at floors where thermal expansion is minimal and will not bind isolator restraints. For risers in pipe shafts, specification SC cable restraints shall be installed at each level in a manner that does not interfere with thermal movement.

Piping Restraints:

5. Comply with requirements in MSS SP-127.
6. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.
7. Brace a change of direction longer than 12 feet.

Install cables so they do not bend across edges of adjacent equipment or building structure.

Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction providing required submittals for component.

Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.

Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

Drilled-in Anchors:

8. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
9. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
10. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
11. Set anchors to manufacturer's recommended torque, using a torque wrench.
12. Install zinc-coated steel anchors for interior and stainless steel anchors for exterior applications.

DUCT WORK

13. Duct work 6 square feet and larger in cross sectional area shall be protected in all planes by SC restraints. Locations shall be determined by the isolator supplier and shall include, but not be limited to:
   a. At equipment connections as required to protect the connections.
   b. At all duct runs and duct run ends (transverse bracing and longitudinal bracing not to exceed spacing specified in SMACNA guidelines).
14. The isolation and/or seismic restraints listed shall be furnished and installed for the equipment listed in the vibration Control and Seismic Restraint device schedule table below in accordance with the previous sections of this specification:

3.6 APPLICATIONS

Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an agency acceptable to authorities having jurisdiction.

Hanger Rod Stiffeners: Install hanger rod stiffeners where required to prevent buckling of hanger rods due to seismic forces.

Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits.

3.7 VIBRATION-CONTROL AND SEISMIC-RESTRAINT DEVICE INSTALLATION

Equipment Restraints:

1. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inches.
2. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction providing required submittals for component.

3.8 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

Install flexible connections in piping where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment. Comply with requirements in Division 22 Section "Domestic Water Piping" for piping flexible connections.

3.9 FIELD QUALITY CONTROL

Perform tests and inspections.

Tests and Inspections:

1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.
4. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
5. Test to 90 percent of rated proof load of device.
7. Measure isolator deflection.
8. If a device fails test, modify all installations of same type and retest until satisfactory results are achieved.

Remove and replace malfunctioning units and retest as specified above.

Prepare test and inspection reports.

3.10 ADJUSTING

Adjust isolators after piping system is at operating weight.

Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

Adjust active height of spring isolators.

Adjust restraints to permit free movement of equipment within normal mode of operation.
### 3.11 VIBRATION-CONTROL AND SEISMIC-RESTRAINT DEVICE SCHEDULE

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Importance Factor</th>
<th>Location</th>
<th>Application</th>
<th>Isolation Required</th>
<th>Anchor Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Heater Storage Tank</td>
<td>1.0</td>
<td>Basement</td>
<td>Floor Mounted</td>
<td>None</td>
<td>Specification SL (Amber Booth Type ER or equal) and SC</td>
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<tr>
<td>Air Compressor</td>
<td>1.0</td>
<td>Basement</td>
<td>Floor Mounted</td>
<td>3/4&quot; deflection Specification SB</td>
<td>(Amber/Booth SWSR or equal)</td>
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<tr>
<td>ET-1, 2, 3, 4, 5, PET-1</td>
<td>1.0</td>
<td>Basement</td>
<td>Floor Mounted</td>
<td>None</td>
<td>Anchor Bolts with Elastomeric Grommets</td>
</tr>
<tr>
<td>Heat Pumps - floor mounted</td>
<td>1.0</td>
<td>Varies</td>
<td>Floor Mounted</td>
<td>2&quot; deflection, Specification C (Amber Booth</td>
<td>Model CTER or equal)</td>
</tr>
<tr>
<td>Suspended Heat Pumps</td>
<td>1.0</td>
<td>Varies</td>
<td>Suspended</td>
<td>Specification E: Amber/Booth Type BSRA (or</td>
<td>equal).</td>
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<td>Buffer Tank BT-1, 2</td>
<td>1.0</td>
<td>Basement</td>
<td>Floor Mounted</td>
<td>None</td>
<td>Anchor Bolts with Elastomeric Grommets</td>
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<tr>
<td>AGF-1, 2</td>
<td>1.0</td>
<td>Basement</td>
<td>Floor Mounted</td>
<td>None</td>
<td>Anchor Bolts with Elastomeric Grommets</td>
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<tr>
<td>Cabinet unit heaters</td>
<td>1.0</td>
<td>various</td>
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<td>None</td>
<td>Specification SC (Amber Booth Type LRC or equal)</td>
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<td>Pump P-HW1, HW2, P-GS1, P-GS2,</td>
<td>1.0</td>
<td>Basement</td>
<td>Floor Mounted</td>
<td>Specification W (Amber/Booth Type NRC or</td>
<td>equal). See Drawings for Detail</td>
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<td>P-HP1, P-HP2</td>
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<td></td>
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<td>DOAS-1, AHU-1, ECON-1</td>
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<td>varies</td>
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<td>2&quot; deflection seismic spring isolators, Speci-</td>
<td>fication C (Amber Booth Model CTER or equal)</td>
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<td>DWH-1 Domestic water heat pump</td>
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<td>Floor Mounted</td>
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<td>Anchor Bolts</td>
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<td>Air Separator AS-1, AS-2, AS-3</td>
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<td>Basement</td>
<td>Suspended</td>
<td>None</td>
<td>Specification SC (Amber Booth Type LRC or equal)</td>
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<td>Suspended Centrifugal fans</td>
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<td>varies</td>
<td>Suspended</td>
<td>3/4&quot; deflection Specification SB</td>
<td>(Amber/Booth SWSR or equal)</td>
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<td>up to 15 hp</td>
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<td></td>
<td></td>
<td></td>
<td>Specification SC (Amber Booth Type LRC or equal)</td>
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<td>Roof Mounted</td>
<td>3/4&quot; deflection Specification SB</td>
<td>(Amber/Booth SWSR or equal)</td>
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<td>S1, S2, S3 and other utility</td>
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<tr>
<td>sets</td>
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<td>Steam to HW Heat Exchangers HX-</td>
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<td>Basement</td>
<td>Floor Mounted</td>
<td>None</td>
<td>Anchor Bolts</td>
</tr>
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<td>1, HX-2</td>
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<td></td>
<td>on welded frame</td>
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<td></td>
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<td>Unit Heaters</td>
<td>1.0</td>
<td>various</td>
<td>Suspended</td>
<td>None</td>
<td>Specification SC (Amber Booth Type LRC or equal)</td>
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<td>Duct mounted components</td>
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<td>Varies</td>
<td>Suspended</td>
<td>None</td>
<td>Specification SC (Amber Booth Type LRC or equal)</td>
</tr>
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<td>&gt;76 lbs (airflow valves, humid-</td>
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<td>ifiers, heating coils, VAV box-</td>
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<tr>
<td>es, etc.)</td>
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<tr>
<td>Piping and Ductwork</td>
<td>1.0</td>
<td>Varies</td>
<td>Suspended</td>
<td>See requirements within this specification s-</td>
<td>section</td>
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## Equipment Importance Factor Location Application Isolation Required Anchor Type

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<th>Location</th>
<th>Application</th>
<th>Isolation Required</th>
<th>Anchor Type</th>
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<td>Basement</td>
<td>Floor Mounted</td>
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END OF SECTION 23 05 48
SECTION 23 05 53 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Equipment labels.
   2. Warning signs and labels.
   3. Pipe labels.
   4. Duct labels.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Metal Labels for Equipment:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Brady Corporation.
      b. Brimar Industries, Inc.
      c. Carlton Industries, LP.
      d. Champion America.
      e. Craftmark Pipe Markers.
      f. emedco.
      g. Kolbi Pipe Marker Co.
      h. LEM Products Inc.
      i. Marking Services, Inc.
      j. Seton Identification Products.
   2. Material and Thickness: aluminum, 0.032-inch or anodized aluminum, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
   4. Background Color: Black.
   5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
   6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
   7. Fasteners: Stainless-steel rivets or self-tapping screws.
   8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
B. Plastic Labels for Equipment:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Brady Corporation.
   b. Brimar Industries, Inc
   c. Carlton Industries, LP.
   d. Champion America.
   e. Craftmark Pipe Markers.
   f. emedco.
   g. Kolbi Pipe Marker Co.
   h. LEM Products Inc.
   i. Marking Services, Inc.
   j. Seton Identification Products.

2. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.
4. Background Color: Black.
5. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
6. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
7. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
9. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

C. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), and the Specification Section number and title where equipment is specified.

D. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number, and identify Drawing numbers where equipment is indicated (plans, details, and schedules) and the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.2 WARNING SIGNS AND LABELS

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

1. Brady Corporation.
2. Brimar Industries, Inc
3. Carlton Industries, LP.
5. Craftmark Pipe Markers.
6. emedco.
7. LEM Products Inc.
8. Marking Services, Inc.
9. National Marker Company
10. Seton Identification Products.
11. Stranco, Inc.
B. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.

C. Letter Color: Black.

D. Background Color: Yellow.

E. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

F. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

G. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.

H. Fasteners: Stainless-steel rivets or self-tapping screws.

I. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

J. Label Content: Include caution and warning information plus emergency notification instructions.

2.3 PIPE LABELS

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

1. Actioncraft Products, Inc.
2. Brady Corporation.
3. Brimar Industries, Inc
4. Carlton Industries, LP.
5. Champion America.
7. emedco.
8. Kolbi Pipe Marker Co
9. LEM Products Inc.
10. Marking Services, Inc.
11. Seton Identification Products.

B. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction according to ASME A13.1.

C. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.

D. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

E. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings; also include pipe size and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions or as separate unit on each pipe label to indicate flow direction.
2. Lettering Size: At least 1/2 inch for viewing distances up to 72 inches and proportionately larger lettering for greater viewing distances.
2.4 DUCT LABELS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Brady Corporation.
   2. Brimar Industries, Inc.
   3. Carlton Industries, LP.
   5. Craftmark Pipe Markers.
   6. emedco.
   7. Kolbi Pipe Marker Co
   8. LEM Products Inc.
   9. Marking Services, Inc.
   10. Seton Identification Products.

B. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.


D. Background Color: Black.

E. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

F. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

G. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.

H. Fasteners: Stainless-steel rivets or self-tapping screws.

I. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

J. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings; also include duct size and an arrow indicating flow direction.
   1. Flow-Direction Arrows: Integral with duct system service lettering to accommodate both directions or as separate unit on each duct label to indicate flow direction.

PART 3 - EXECUTION

3.1 PREPARATION

A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.2 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of mechanical equipment.
B. Locate equipment labels where accessible and visible.

3.3 PIPE LABEL INSTALLATION

A. Pipe Label Locations: Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:

1. Near each valve and control device.
2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations and on both sides of through walls, floors, ceilings, and inaccessible enclosures.
4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 25 feet along each run. Reduce intervals to 15 feet in areas of congested piping and equipment.

B. Pipe Label Color Schedule:

4. Low-Pressure Steam Piping: White letters on a safety-purple background.
5. High-Pressure Steam Piping: White letters on a safety-purple background.

3.4 DUCT LABEL INSTALLATION

A. Install self-adhesive duct labels with permanent adhesive on air ducts in the following color codes:

1. Blue: For cold-air supply ducts.
2. Yellow: For hot-air supply ducts.

B. Locate labels near points where ducts enter into and exit from concealed spaces and at maximum intervals of 50 feet in each space where ducts are exposed or concealed by removable ceiling system.
SECTION 23 05 93 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Balancing Air Systems:
   a. Constant-volume air systems.
   b. Variable-air-volume systems.

2. Balancing Hydronic Piping Systems:
   a. Constant-flow hydronic systems.
   b. Variable-flow hydronic systems.

1.2 DEFINITIONS

C. TAB: Testing, adjusting, and balancing.
D. TABB: Testing, Adjusting, and Balancing Bureau.
E. TAB Specialist: An entity engaged to perform TAB Work.

1.3 ACTION SUBMITTALS

A. LEED Submittals:

1. Air-Balance Report for Prerequisite IEQ 1: Documentation of work performed for ASHRAE 62.1, Section 7.2.2 - "Air Balancing."
2. TAB Report for Prerequisite EA 2: Documentation of work performed for ASHRAE/IESNA 90.1, Section 6.7.2.3 - "System Balancing."

1.4 INFORMATIONAL SUBMITTALS

A. Certified TAB reports.

1.5 QUALITY ASSURANCE

A. TAB Contractor Qualifications: Engage a TAB entity certified by NEBB.
1. **TAB Field Supervisor:** Employee of the TAB contractor and certified by NEBB.
2. **TAB Technician:** Employee of the TAB contractor and who is certified by NEBB as a TAB technician.

**B. Certify TAB field data reports and perform the following:**

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

**C. TAB Report Forms:** Use standard TAB contractor's forms approved by Engineer and Commissioning Authority.

**D. Instrumentation Type, Quantity, Accuracy, and Calibration:** As described in ASHRAE 111, Section 5, "Instrumentation."

**E. ASHRAE Compliance:** Applicable requirements in ASHRAE 62.1, Section 7.2.2 - "Air Balancing."

**F. ASHRAE/IESNA Compliance:** Applicable requirements in ASHRAE/IESNA 90.1, Section 6.7.2.3 - "System Balancing."

**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.

**B.** Examine systems for installed balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are accessible.

**C.** Examine the approved submittals for HVAC systems and equipment.

**D.** Examine design data including HVAC system descriptions, statements of design assumptions for environmental conditions and systems' output, and statements of philosophies and assumptions about HVAC system and equipment controls.

**E.** Examine ceiling plenums and underfloor air plenums used for supply, return, or relief air to verify that they meet the leakage class of connected ducts as specified in Section 23 31 13 "Metal Ducts" and are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed and fire-stopped if required.

**F.** Examine equipment performance data including fan and pump curves.

1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.

G. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.

H. Examine test reports specified in individual system and equipment Sections.

I. Examine HVAC equipment and filters and verify that bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.

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

K. Examine strainers. Verify that startup screens are replaced by permanent screens with indicated perforations.

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

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

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

O. Examine operating safety interlocks and controls on HVAC equipment.

P. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.2 PREPARATION

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

B. Complete system-readiness checks and prepare 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 NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and in this Section.

1. Comply with requirements in ASHRAE 62.1, Section 7.2.2 - "Air Balancing."

B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.

1. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.
2. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Section 23 07 13 "Duct Insulation," Section 23 07 16 "HVAC Equipment Insulation," Section 23 07 19 "HVAC Piping Insulation."

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

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

3.4 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.

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

D. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.

E. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.

F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

G. Verify that motor starters are equipped with properly sized thermal protection.

H. Check dampers for proper position to achieve desired airflow path.

I. Check for airflow blockages.

J. Check condensate drains for proper connections and functioning.

K. Check for proper sealing of air-handling-unit components.

L. Verify that air duct system is sealed as specified in Section 23 31 13 "Metal Ducts."
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 total airflow.
   a. Where sufficient space in ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow.

2. Measure fan static pressures as follows to determine actual static pressure:
   a. Measure outlet static pressure as far downstream from the fan as practical 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 the 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.

3. Measure static pressure across each component that makes up an air-handling unit, rooftop unit, and other air-handling and -treating equipment.
   a. Report the cleanliness status of filters and the time static pressures are measured.

4. Measure static pressures entering and leaving other devices, such as sound traps, heat-recovery equipment, and air washers, under final balanced conditions.
5. Review Record Documents to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
6. Obtain approval from Engineer and Commissioning Authority for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
7. 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 mode 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 airflow of submain and branch ducts.
   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. Measure static pressure at a point downstream from the balancing damper, and adjust volume dampers until the proper static pressure is achieved.
3. 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 air 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 air outlets and inlets for each space to indicated airflows within specified tolerances of indicated values. Make adjustments using branch 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 minimum set-point airflow with the remainder at maximum 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 outdoor-air dampers at minimum, and set 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 the 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 the same 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 the same 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 outdoor airflow.
   a. Adjust the fan and balance the return-air ducts and inlets the same as described for constant-volume air systems.
7. Measure static pressure at the most critical terminal unit and adjust the static-pressure controller at the main supply-air sensing station to ensure that adequate static pressure is maintained at the most critical unit.
8. Record final fan-performance data.

C. Pressure-Dependent, Variable-Air-Volume Systems without Diversity: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:
1. Balance variable-air-volume systems the same as described for constant-volume air systems.
2. Set terminal units and supply fan at full-airflow condition.
3. Adjust inlet dampers of each terminal unit to indicated airflow and verify operation of the static-pressure controller. When total airflow is correct, balance the air outlets downstream from terminal units the same as described for constant-volume air systems.
4. Readjust fan airflow for final maximum readings.
5. Measure operating static pressure at the sensor that controls the supply fan if one is installed, and verify operation of the static-pressure controller.
6. Set supply fan at minimum airflow if minimum airflow is indicated. Measure static pressure to verify that it is being maintained by the controller.
7. 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 the same as described for constant-volume air systems.
   a. If air outlets are out of balance at minimum airflow, report the condition but leave the outlets balanced for maximum airflow.
8. Measure the return airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.
   a. Adjust the fan and balance the return-air ducts and inlets the same as described for constant-volume air systems.

D. Pressure-Dependent, Variable-Air-Volume Systems with Diversity: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:

1. Set system at maximum indicated airflow by setting the required number of terminal units at minimum airflow. Select the reduced-airflow terminal units so they are distributed evenly among the branch ducts.
2. Adjust supply fan to maximum indicated airflow with the variable-airflow controller set at maximum airflow.
3. Set terminal units at full-airflow condition.
4. Adjust terminal units starting at the supply-fan end of the system and continuing progressively to the end of the system. Adjust inlet dampers of each terminal unit to indicated airflow. When total airflow is correct, balance the air outlets downstream from terminal units the same as described for constant-volume air systems.
5. Adjust terminal units for minimum airflow.
6. Measure static pressure at the sensor.
7. Measure the return airflow to the fan while operating at maximum return airflow and minimum outdoor airflow. Adjust the fan and balance the return-air ducts and inlets the same as described for constant-volume air systems.

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 the approved pump flow rate. Correct variations that exceed plus or minus 5 percent.

B. Prepare schematic diagrams of systems' "as-built" piping layouts.

C. 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 liquid level in expansion tank.
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 CONSTANT-FLOW 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.
      a. If impeller sizes must be adjusted to achieve pump performance, obtain approval from Engineer and Commissioning Authority and comply with requirements in Section 23 21 23 "Hydronic Pumps."
   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.
      a. Monitor motor performance during procedures and do not operate motors in overload conditions.
   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 10 percent of design.

B. Measure flow at all automatic flow control valves to verify that valves are functioning as designed.

C. Measure flow at all pressure-independent characterized control valves, with valves in fully open position, to verify that valves are functioning as designed.

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

E. 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.

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

G. 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.

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

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

J. Check settings and operation of each safety valve. Record settings.

3.9 PROCEDURES FOR VARIABLE-FLOW HYDRONIC SYSTEMS

A. Balance systems with automatic two- and three-way control valves by setting systems at maximum flow through heat-exchange terminals and proceed as specified above for hydronic systems.

3.10 PROCEDURES FOR MOTORS

A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:
   1. Manufacturer's name, model number, and serial number.
   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 of the controller to prove proper operation. Record observations including name of controller manufacturer, model number, serial number, and nameplate data.

3.11 PROCEDURES FOR HEAT EXCHANGERS

A. Heat Exchangers: Measure and record entering- and leaving-water temperatures and water flow.

B. Heat Exchangers: Measure and record entering-water temperature and flow and leaving-steam pressure, temperature, and flow.

3.12 PROCEDURES FOR HEAT-TRANSFER COILS

A. Measure, adjust, and record the following data for each water coil:
   1. Entering- and leaving-water temperature.
   2. Water flow rate.
   3. Water pressure drop.
   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. Measure, adjust, and record the following data for each electric heating coil:
   1. Nameplate data.
   2. Airflow.
   3. Entering- and leaving-air temperature at full load.
   4. Voltage and amperage input of each phase at full load and at each incremental stage.
   5. Calculated kilowatt at full load.
   6. Fuse or circuit-breaker rating for overload protection.

C. Measure, adjust, and record the following data for each steam coil:
   1. Dry-bulb temperature of entering and leaving air.
   2. Airflow.
   3. Air pressure drop.
   4. Inlet steam pressure.

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

3.13 TOLERANCES

A. Set HVAC system's air flow rates and water flow rates within the following tolerances:
   1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 10 percent.
   2. Air Outlets and Inlets: Plus or minus 10 percent.
   3. Heating-Water Flow Rate: Plus or minus 10 percent.
   4. Cooling-Water Flow Rate: Plus or minus 10 percent.

3.14 REPORTING

A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for systems' balancing devices. Recommend changes and additions to systems' balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.

B. Status Reports: Prepare monthly progress reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.
3.15 FINAL REPORT

A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.

1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
2. Include a list of instruments used for procedures, along with proof of calibration.

B. Final Report Contents: In addition to certified field-report data, include the following:

1. Pump curves.
2. Fan curves.
3. Manufacturers' test data.
4. Field test reports prepared by system and equipment installers.
5. Other information relative to equipment performance; do not include Shop Drawings and product data.

C. General Report Data: In addition to form titles and entries, include the following data:

1. Title page.
2. Name and address of the TAB contractor.
3. Project name.
4. Project location.
5. Architect's name and address.
6. Engineer's name and address.
7. Contractor's name and address.
9. Signature of TAB supervisor who certifies the report.
10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
11. Summary of contents including the following:
   a. Indicated versus final performance.
   b. Notable characteristics of systems.
   c. Description of system operation sequence if it varies from the Contract Documents.

12. Nomenclature sheets for each item of equipment.
13. Data for terminal units, including manufacturer's name, type, size, and fittings.
14. Notes to explain why certain final data in the body of reports vary from indicated values.
15. Test conditions for fans and pump performance forms including the following:
   a. Settings for outdoor-, return-, and exhaust-air dampers.
   b. Conditions of filters.
   c. Cooling coil, wet- and dry-bulb conditions.
   d. Face and bypass damper settings at coils.
   e. Fan drive settings including settings and percentage of maximum pitch diameter.
   f. Inlet vane settings for variable-air-volume systems.
   g. Settings for supply-air, static-pressure controller.
   h. Other system operating conditions that affect performance.

D. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:

1. Quantities of outdoor, supply, return, and exhaust airflows.
2. Water and steam flow rates.
3. Duct, outlet, and inlet sizes.
4. Pipe and valve sizes and locations.
5. Terminal units.

3.16 ADDITIONAL TESTS

A. Within 90 days of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

END OF SECTION 23 05 93
SECTION 23 07 13 - DUCT INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes insulating the following duct services:

1. Indoor, concealed supply and outdoor air.
2. Indoor, exposed supply and outdoor air.
3. Indoor, concealed return located in unconditioned space.
4. Indoor, exposed return located in unconditioned space.
5. Indoor, concealed oven and warewash exhaust.
6. Indoor, exposed oven and warewash exhaust.
7. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
8. Indoor, exposed exhaust between isolation damper and penetration of building exterior.
9. Outdoor, concealed supply and return.
10. Outdoor, exposed supply and return.

B. Related Sections:

1. Section 23 07 16 "HVAC Equipment Insulation."
2. Section 23 07 19 "HVAC Piping Insulation."
3. Section 23 31 13 "Metal Ducts" for duct liners.

1.2 ACTION SUBMITTALS

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

B. LEED Submittals:

1. Product Data for Credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content.

C. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
2. Detail insulation application at elbows, fittings, dampers, specialties and flanges for each type of insulation.
3. Detail application of field-applied jackets.
4. Detail application at linkages of control devices.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.
1.4 QUALITY ASSURANCE

A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS


B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. Mineral-Fiber 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 "Factory-Applied Jackets" Article.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Certain Teed Corporation
   b. Johns Manville
   c. Knauf Insulation
   d. Manson Insulation
   e. Owens Corning

G. 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. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Certain Teed Corporation
b. Johns Manville  
c. Knauf Insulation  
d. Manson Insulation  
e. Owens Corning

2.2 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

B. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Childers Brand  
b. Eagle Bridges  
c. Foster Brand  
d. Mon-Eco Industries
   2. LEED: For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Childers Brand  
b. Eagle Bridges  
c. Foster Brand  
d. Mon-Eco Industries
   2. LEED: For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

D. PVC Jacket Adhesive: Compatible with PVC jacket.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Dow Corning Corp  
b. Johns Manville  
c. P.I.C. Plastics  
d. Speedline Corp
   2. LEED: For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2.3 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.
   1. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Childers Brand
      b. Eagle Bridges
      c. Foster Brand
      d. Knauf Insulation
      e. Mon-Eco Industries
      f. Vimasco Corp

2.4 SEALANTS

A. FSK and Metal Jacket Flashing Sealants:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Childers Brand
      b. Eagle Bridges
      c. Foster Brand
      d. Mon-Eco Industries

   2. Materials shall be compatible with insulation materials, jackets, and substrates.
   3. Fire- and water-resistant, flexible, elastomeric sealant.
   4. Service Temperature Range: Minus 40 to plus 250 deg F.
   5. Color: Aluminum.
   6. For indoor applications, use sealants that have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   7. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

B. ASJ Flashing Sealants, and Vinyl and PVC Jacket Flashing Sealants:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Childers Brand
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.
6. LEED: For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.5 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.
4. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C 1136, Type II.
5. Vinyl Jacket: White vinyl with a permeance of 1.3 perms when tested according to ASTM E 96/E 96M, Procedure A, and complying with NFPA 90A and NFPA 90B.

2.6 FIELD-APPLIED FABRIC-REINFORCING MESH

A. Woven Polyester Fabric: Approximately 1 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in., in a Leno weave, for ducts.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Foster Brand
   b. Vimasco Corp

2.7 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.

C. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Johns Manville
   b. P.I.C. Plastics
   c. Proto Corp
   d. Speedline Corp
2. Adhesive: As recommended by jacket material manufacturer.

D. Aluminum Jacket: Comply with ASTM B 209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Childers Brand
      b. ITW Insulation Systems
      c. RPR Products Inc.
   2. Factory cut and rolled to size.
   3. Finish and thickness are indicated in field-applied jacket schedules.
   4. Moisture Barrier for Outdoor Applications: 3-mil-thick, heat-bonded polyethylene and kraft paper.

2.8 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying
   with ASTM C 1136.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Avery Dennison Corp
      b. Compac Corp
      c. Ideal Tape Co
      d. Knauf Insulation
      e. Venture Tape
   2. Width: 3 inches.
   3. Thickness: 11.5 mils.
   5. Elongation: 2 percent.
   6. Tensile Strength: 40 lbf/inch in width.
   7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying
   with ASTM C 1136.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Avery Dennison Corp
      b. Compac Corp
      c. Ideal Tape Co
      d. Knauf Insulation
      e. Venture Tape
   2. Width: 3 inches.
   3. Thickness: 6.5 mils.
   5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Compac Corp
      b. Ideal Tape Co
      c. Venture Tape
   2. Width: 2 inches.
   3. Thickness: 6 mils.
   5. Elongation: 500 percent.
   6. Tensile Strength: 18 lbf/inch in width.

D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Avery Dennison Corp
      b. Compac Corp
      c. Ideal Tape Co
      d. Knauf Insulation
      e. Venture Tape
   2. Width: 2 inches.
   3. Thickness: 3.7 mils.
   5. Elongation: 5 percent.
   6. Tensile Strength: 34 lbf/inch in width.

2.9 SECUREMENTS

A. Aluminum Bands: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 3/4 inch wide with wing seal or closed seal.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. ITW Insulation Systems
      b. RPR Products, Inc.

B. Insulation Pins and Hangers:
   1. Metal, 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. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1) AMG Industries Inc
   2) Gemco
   3) Midwest Fasteners, Inc.

b. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
c. Spindle: Stainless steel, fully annealed, 0.106-inch-diameter shank, length to suit depth of insulation indicated.
d. Adhesive: Welded

2. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

C. Staples: Outward-clinching insulation staples, nominal 3/4-inch-wide, stainless steel or Monel.

D. Wire: 0.062-inch soft-annealed, stainless steel.

2.10 CORNER ANGLES

A. PVC Corner Angles: 30 mils thick, minimum 1 by 1 inch, PVC according to ASTM D1784, Class 16354-C. White or color-coded to match adjacent surface.

B. Aluminum Corner Angles: 0.040 inch thick, minimum 1 by 1 inch, aluminum according to ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14.

PART 3 - EXECUTION

3.1 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

3.2 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of ducts and fittings.

B. Install insulation materials, vapor barriers or retarders, jackets, and thicknesses required for each item of duct system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.
F. Keep insulation materials dry during application and finishing.

G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

H. Install insulation with least number of joints practical.

I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
   1. Install insulation continuously through hangers and around anchor attachments.
   2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
   3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.

J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

K. Install insulation with factory-applied jackets as follows:
   1. Draw jacket tight and smooth.
   2. Cover circumferential joints with 3-inch-wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
   3. Overlap jacket longitudinal seams at least 1-1/2 inches. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 4 inches o.c.
      a. For below ambient services, apply vapor-barrier mastic over staples.
   4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
   5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct flanges and fittings.

L. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

3.3 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
   1. Seal penetrations with flashing sealant.
   2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
   1. Seal penetrations with flashing sealant.
   2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
   3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
   4. Seal jacket to wall flashing with flashing sealant.

C. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

D. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches.
   1. Comply with requirements in Section 07 84 13 "Penetration Firestopping" for firestopping and fire-resistant joint sealers.

E. Insulation Installation at Floor Penetrations:
   1. Duct: For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches.
   2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 07 84 13 "Penetration Firestopping."

3.4 INSTALLATION OF MINERAL-FIBER INSULATION

A. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
   1. Apply adhesives according to manufacturer’s recommended coverage rates per unit area, for 50 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 one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
   a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
   b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.

5. Overlap unfaced blankets a minimum of 2 inches on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches o.c.

6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.

7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch-wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

B. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 50 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 one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
   a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.

5. 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.

3.5 FIELD-APPLIED JACKET INSTALLATION

A. 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.

B. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturer’s recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

C. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

3.6 FIRE-RATED INSULATION SYSTEM INSTALLATION

A. Where fire-rated insulation system is indicated, secure system to ducts and duct hangers and supports to maintain a continuous fire rating.

B. Insulate duct access panels and doors to achieve same fire rating as duct.

C. Install firestopping at penetrations through fire-rated assemblies. Fire-stop systems are specified in Section 07 84 13 "Penetration Firestopping."

3.7 FINISHES

A. Insulation with ASJ or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 09 91 13 "Exterior Painting" and Section 09 91 23 "Interior Painting."
1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.

B. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

C. Do not field paint aluminum or stainless-steel jackets.

3.8 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:
   1. Inspect ductwork, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location(s) for each duct system defined in the "Duct Insulation Schedule, General" Article.

C. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.9 DUCT INSULATION SCHEDULE, GENERAL

A. Plenums and Ducts Requiring Insulation:
   1. Indoor, concealed supply and outdoor air.
   2. Indoor, exposed supply and outdoor air.
   3. Indoor, concealed return located in unconditioned space.
   4. Indoor, exposed return located in unconditioned space.
   5. Indoor, concealed oven and warewash exhaust.
   6. Indoor, exposed oven and warewash exhaust.
   7. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
   8. Indoor, exposed exhaust between isolation damper and penetration of building exterior.
   9. Outdoor, concealed supply and return.
   10. Outdoor, exposed supply and return.

B. Items Not Insulated:
   1. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1.
   2. Factory-insulated flexible ducts.
   3. Factory-insulated plenums and casings.
   4. Flexible connectors.
   5. Vibration-control devices.
   6. Factory-insulated access panels and doors.
3.10 INDOOR DUCT AND PLENUM INSULATION SCHEDULE (R-5 Minimum)

A. Concealed, Supply-Air Duct and Plenum Insulation: Mineral-fiber blanket, 1-1/2 inches thick and 0.75-lb/cu. ft. nominal density.

B. Concealed, Outdoor-Air Duct and Plenum Insulation: Mineral-fiber blanket, 1-1/2 inches thick and 0.75-lb/cu. ft. nominal density.

C. Concealed, Exhaust-Air Duct and Plenum Insulation: Mineral-fiber blanket, 1-1/2 inches thick and 0.75-lb/cu. ft. nominal density.

D. Concealed, Type I, Commercial, Kitchen Hood Exhaust Duct and Plenum Insulation: Fire-rated blanket; thickness as required to achieve 2-hour fire rating.

E. Exposed, Supply-Air Duct and Plenum Insulation: Mineral-fiber blanket, 1-1/2 inches thick and 0.75-lb/cu. ft. nominal density.

F. Exposed, Outdoor-Air Duct and Plenum Insulation: Mineral-fiber blanket, 1-1/2 inches thick and 0.75-lb/cu. ft. nominal density.

G. Exposed, Exhaust-Air Duct and Plenum Insulation: Mineral-fiber blanket, 1-1/2 inches thick and 0.75-lb/cu. ft. nominal density.

3.11 ABOVEGROUND, OUTDOOR DUCT AND PLENUM INSULATION SCHEDULE (R-8 Minimum)

A. Insulation materials and thicknesses are identified below. If more than one material is listed for a duct system, selection from materials listed is Contractor's option.

B. Concealed, Supply-Air Duct and Plenum Insulation: Mineral-fiber board, 2 inches thick and 3.5-lb/cu. ft. nominal density.

C. Concealed, Return-Air Duct and Plenum Insulation: Mineral-fiber board, 2 inches thick and 3.5-lb/cu. ft. nominal density.

D. Concealed, Outdoor-Air Duct and Plenum Insulation: Mineral-fiber board, 2 inches thick and 3.5-lb/cu. ft. nominal density.

E. Exposed, Supply-Air Duct and Plenum Insulation: Mineral-fiber board, 2 inches thick and 3.5-lb/cu. ft. nominal density.

F. Exposed, Return-Air Duct and Plenum Insulation: Mineral-fiber board, 2 inches thick and 3.5-lb/cu. ft. nominal density.

3.12 INDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Ducts and Plenums, Concealed:
1. None.

D. Ducts and Plenums, Exposed:

1. None.

3.13 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Ducts and Plenums, Concealed:

1. None.

D. Ducts and Plenums, Exposed, up to 48 Inches in Diameter or with Flat Surfaces up to 72 Inches:

1. Aluminum, Stucco Embossed: 0.024 inch thick.

E. Ducts and Plenums, Exposed, Larger Than 48 Inches in Diameter or with Flat Surfaces Larger Than 72 Inches:

1. Aluminum, Stucco Embossed with 1-1/4-Inch-Deep Corrugations: 0.040 inch thick.

END OF SECTION 23 07 13
SECTION 23 07 19 - HVAC PIPING INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes insulating the following HVAC piping systems:
   1. Heating hot-water piping, indoors and outdoors.
   2. Heat Pump Loop piping, indoors and outdoors.

B. Related Sections:
   1. Section 23 07 13 "Duct Insulation."
   2. Section 23 07 16 "HVAC Equipment Insulation."

1.2 ACTION SUBMITTALS

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

B. LEED Submittals:
   1. Product Data for Credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content.

C. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
   1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
   2. Detail attachment and covering of heat tracing inside insulation.
   3. Detail insulation application at pipe expansion joints for each type of insulation.
   4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
   5. Detail removable insulation at piping specialties.
   6. Detail application of field-applied jackets.
   7. Detail application at linkages of control devices.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing and inspecting agency acceptable to authorities having
jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and 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.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Products shall not contain asbestos, lead, mercury, or mercury compounds.

B. 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.

C. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

D. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

E. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in “Factory-Applied Jackets” Article.

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

2. Block Insulation: ASTM C 552, Type I.
3. Special-Shaped Insulation: ASTM C 552, Type III.
4. Board Insulation: ASTM C 552, Type IV.
5. Preformed Pipe Insulation without Jacket: Comply with ASTM C 552, Type II, Class 1.
7. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.

F. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Aeroflex USA, Inc.
   b. Armacell LLC
   c. K-Flex USA

G. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 1290, Type I.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. CertainTeed Corp
   b. Johns Manville
   c. Knauf Insulation
   d. Manson Insulation
   e. Owens Corning

H. Mineral-Fiber, Preformed Pipe Insulation:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Johns Manville
   b. Knauf Insulation
   c. Manson Insulation
   d. Owens Corning

2. Type I, 850 deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ-SSL. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

3. Type II, 1200 deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type II, Grade A, with factory-applied ASJ-SSL. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

I. Polyolefin: Unicellular, polyethylene thermal plastic insulation. Comply with ASTM C 534 or ASTM C 1427, Type I, Grade 1 for tubular materials and Type II, Grade 1 for sheet materials.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Armacell LLC
   b. Nomaco Insulation


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

2.2 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. Cellular-Glass Adhesive: Two-component, thermosetting urethane adhesive containing no flammable solvents, with a service temperature range of minus 100 to plus 200 deg F.

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

2. LEED: For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Aeroflex USA, Inc.
      b. Armacell LLC
      c. Foster Brand
      d. K-Flex
   2. LEED: For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

D. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Childers Brand
      b. Eagle Bridges
      c. Foster Brand
      d. Mon-Eco Industries, Inc.
   2. LEED: For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Childers Brand
      b. Eagle Bridges
      c. Foster Brand
      d. Mon-Eco Industries, Inc.
   2. LEED: For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

F. PVC Jacket Adhesive: Compatible with PVC jacket.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Dow Corning Corp
      b. Johns Manville
      c. P.I.C. Plastics, Inc.
      d. Speedline Corp
2. LEED: For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.3 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.

1. LEED: For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below-ambient services.

   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Foster Brand
      b. Vimasco Corp

   2. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm at 43-mil dry film thickness.
   3. Service Temperature Range: Minus 20 to plus 180 deg F.
   4. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.

C. Breather Mastic: Water based; suitable for indoor and outdoor use on above-ambient services.

   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Childers Brand
      b. Eagle Bridges
      c. Foster Brand
      d. Knauf Insulation
      e. Mon-Eco Industries, Inc.
      f. Vimasco Corp

   2. Water-Vapor Permeance: ASTM F 1249, 1.8 perms at 0.0625-inch dry film thickness.
   3. Service Temperature Range: Minus 20 to plus 180 deg F.
   4. Solids Content: 60 percent by volume and 66 percent by weight.

2.4 SEALANTS

A. Joint Sealants:

   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Childers Brand
      b. Eagle Bridges
      c. Foster Brand
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 or gray.
6. LEED: For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. FSK and Metal Jacket Flashing Sealants:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Childers Brand
   b. Eagle Bridges
   c. Foster Brand
   d. Mon-Eco Industries, Inc.

2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F.
5. Color: Aluminum.
6. LEED: For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:

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

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.
6. LEED: For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.5 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.
4. **FSP Jacket:** Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C 1136, Type II.

5. **PVDC Jacket for Indoor Applications:** 4-mil thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perm when tested according to ASTM E 96/E 96M and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.
   
   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      
      1) ITW Insulation Systems

6. **PVDC Jacket for Outdoor Applications:** 6-mil thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perm when tested according to ASTM E 96/E 96M and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E 84.
   
   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      
      1) ITW Insulation Systems

7. **PVDC-SSL Jacket:** PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.
   
   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      
      1) ITW Insulation Systems

8. **Vinyl Jacket:** White vinyl with a permeance of 1.3 perms when tested according to ASTM E 96/E 96M, Procedure A, and complying with NFPA 90A and NFPA 90B.

### 2.6 FIELD-APPLIED FABRIC-REINFORCING MESH

A. **Woven Polyester Fabric:** Approximately 1 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in., in a Leno weave, for pipe.
   
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      
      a. Foster Brand
      b. Vimasco Corp

### 2.7 FIELD-APPLIED JACKETS

A. **Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.**

B. **FSK Jacket:** Aluminum-foil face, fiberglass-reinforced scrim with kraft-paper backing.

C. **PVC Jacket:** High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Johns Manville
   b. P.I.C. Plastics, Inc.
   c. Proto Corporation
   d. Speedline Corp

2. Adhesive: As recommended by jacket material manufacturer.


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, mechanical joints, and P-trap and supply covers for lavatories.

D. Aluminum Jacket: Comply with ASTM B 209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Childers Brand
   b. ITW Insulation Systems
   c. RPR Products

2. Factory cut and rolled to size.

3. Finish and thickness are indicated in field-applied jacket schedules.

4. Moisture Barrier for Outdoor Applications: 3-mil-thick, heat-bonded polyethylene and kraft paper.

5. Factory-Fabricated Fitting Covers:
   a. Same material, finish, and thickness as jacket.
   b. Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
   c. Tee covers.
   d. Flange and union covers.
   e. End caps.
   f. Beveled collars.
   g. Valve covers.
   h. Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

E. PVDC Jacket for Indoor Applications: 4-mil-thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perms when tested according to ASTM E 96/E 96M and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.

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

F. PVDC Jacket for Outdoor Applications: 6-mil-thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perms when tested according to ASTM E 96/E 96M and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E 84.

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

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

2.8 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Avery Dennison Corp
   b. Compac Corp
   c. Ideal Tape Co Inc.
   d. Knauf Insulation
   e. Venture Tape

2. Width: 3 inches.
3. Thickness: 11.5 mils.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Avery Dennison Corp
   b. Compac Corp
   c. Ideal Tape Co Inc.
   d. Knauf Insulation
   e. Venture Tape

2. Width: 3 inches.
3. Thickness: 6.5 mils.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Compac Corp
   b. Ideal Tape Co Inc.
   c. Venture Tape

2. Width: 2 inches.
3. Thickness: 6 mils.
5. Elongation: 500 percent.
6. Tensile Strength: 18 lbf/inch in width.

D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Avery Dennison Corp
   b. Compac Corp
   c. Ideal Tape Co Inc.
   d. Knauf Insulation
   e. Venture Tape

2. Width: 2 inches.
3. Thickness: 3.7 mils.
5. Elongation: 5 percent.
6. Tensile Strength: 34 lbf/inch in width.

E. PVDC Tape for Indoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.

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

2. Width: 3 inches.
3. Film Thickness: 4 mils.
4. Adhesive Thickness: 1.5 mils.
5. Elongation at Break: 145 percent.
6. Tensile Strength: 55 lbf/inch in width.

F. PVDC Tape for Outdoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.

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

2. Width: 3 inches.
3. Film Thickness: 6 mils.
4. Adhesive Thickness: 1.5 mils.
5. Elongation at Break: 145 percent.
6. Tensile Strength: 55 lbf/inch in width.

2.9 SECUREMENTS

A. Aluminum Bands: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 3/4 inch wide with wing seal or closed seal.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. ITW Insulation Systems
   b. RPR Products Inc.

B. Staples: Outward-clinching insulation staples, nominal 3/4-inch wide, stainless steel or Monel.

C. Wire: 0.062-inch soft-annealed, stainless steel.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. C & F Wire

PART 3 - EXECUTION

3.1 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

B. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

C. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.2 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping including fittings, valves, and specialties.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of pipe system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.
F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

G. Keep insulation materials dry during application and finishing.

H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

I. Install insulation with least number of joints practical.

J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

L. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch-wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 4 inches o.c.

   a. For below-ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.

M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

P. For above-ambient services, do not install insulation to the following:

1. Vibration-control devices.
2. Testing agency labels and stamps.
3. Nameplates and data plates.
3.3 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
   1. Seal penetrations with flashing sealant.
   2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
   3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
   4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.

C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
   1. Seal penetrations with flashing sealant.
   2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
   3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
   4. Seal jacket to wall flashing with flashing sealant.

D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.
   1. Comply with requirements in Section 07 84 13 "Penetration Firestopping" for firestopping and fire-resistant joint sealers.

F. Insulation Installation at Floor Penetrations:
   1. Pipe: Install insulation continuously through floor penetrations.
   2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 07 84 13 "Penetration Firestopping."

3.4 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 and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.

9. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.

C. Insulate instrument connections for thermometers, pressure gauges, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

D. Install removable insulation covers at locations indicated. Installation shall conform to the following:

1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.

2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.

3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.

4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover
assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.

5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.5 INSTALLATION OF CELLULAR-GLASS INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above-ambient services, secure laps with outward-clinched staples at 6 inches o.c.
4. For insulation with factory-applied jackets on below-ambient services, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with 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.

3.6 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

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.

3.7 INSTALLATION OF MINERAL-FIBER PREFORMED PIPE INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above-ambient surfaces, secure laps with outward-clinched staples at 6 inches o.c.
4. For insulation with factory-applied jackets on below-ambient surfaces, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:
   1. Install preformed sections of same material as straight segments of pipe insulation when available.
   2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
   3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
   4. Install insulation to flanges as specified for flange insulation application.

3.8 INSTALLATION OF POLYOLEFIN INSULATION

A. Insulation Installation on Straight Pipes and Tubes:
   1. Seal split-tube 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 polyolefin 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 polyolefin 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 cut sections of polyolefin pipe and sheet 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.
   4. Secure insulation to valves and specialties, and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.9 FIELD-APPLIED JACKET INSTALLATION

A. 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.

B. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications. Seal with manufacturer's recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

C. 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.

D. Where PVDC jackets are indicated, install as follows:

1. Apply three separate wraps of filament tape per insulation section to secure pipe insulation to pipe prior to installation of PVDC jacket.
2. Wrap factory-presized jackets around individual pipe insulation sections with one end overlapping the previously installed sheet. Install presized jacket with an approximate overlap at butt joint of 2 inches over the previous section. Adhere lap seal using adhesive or SSL, and then apply 1-1/4 circumferences of appropriate PVDC tape around overlapped butt joint.
3. Continuous jacket can be spiral-wrapped around a length of pipe insulation. Apply adhesive or PVDC tape at overlapped spiral edge. When electing to use adhesives, refer to manufacturer's written instructions for application of adhesives along this spiral edge to maintain a permanent bond.
4. Jacket can be wrapped in cigarette fashion along length of roll for insulation systems with an outer circumference of 33-1/2 inches or less. The 33-1/2-inch-circumference limit allows for 2-inch-overlap seal. Using the length of roll allows for longer sections of jacket to be installed at one time. Use adhesive on the lap seal. Visually inspect lap seal for "fishmouthing," and use PVDC tape along lap seal to secure joint.
5. Repair holes or tears in PVDC jacket by placing PVDC tape over the hole or tear and wrapping a minimum of 1-1/4 circumferences to avoid damage to tape edges.

3.10 FINISHES

A. Pipe Insulation with ASJ or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 09 91 13 "Exterior Painting" and Section 09 91 23 "Interior Painting."

1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.


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.

3.11 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Inspect pipe, fittings, strainers, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three locations of straight pipe, three locations of threaded fittings, three locations of welded fittings, two locations of threaded strainers, two locations of welded strainers, three locations of threaded valves, and three locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.

C. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.12 PIPING INSULATION SCHEDULE, GENERAL

A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.

B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:

1. Drainage piping located in crawl spaces.
2. Underground piping.
3. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.13 INDOOR PIPING INSULATION SCHEDULE

<table>
<thead>
<tr>
<th>System</th>
<th>Pipe Size and Location</th>
<th>Insulation Type and Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steam Piping</td>
<td>Indoors, Less than 12&quot;</td>
<td>3-inch fiberglass Insulation with ASJ Vapor Barrier Jacket</td>
</tr>
<tr>
<td>Condensate Piping</td>
<td>Indoors 1&quot; and larger</td>
<td>2-inch fiberglass Insulation with ASJ Vapor Barrier Jacket</td>
</tr>
<tr>
<td>Condensate Piping</td>
<td>Indoors 3/4&quot; and smaller</td>
<td>1.5inch fiberglass Insulation with ASJ Vapor Barrier Jacket</td>
</tr>
<tr>
<td>Heating Hot Water 200 deg F and below</td>
<td>Indoors, Less than 1.5&quot;</td>
<td>1.5-inch fiberglass Insulation with ASJ Vapor Barrier Jacket</td>
</tr>
<tr>
<td>Heating Hot Water 200 deg F and below</td>
<td>Indoors 1.5&quot; and larger</td>
<td>2-inch fiberglass Insulation with ASJ Vapor Barrier Jacket</td>
</tr>
<tr>
<td>Heat Pump Loop Piping (20 Deg F to 90 deg F)</td>
<td>Indoors, Less than 1.5&quot;</td>
<td>1-inch fiberglass Insulation with ASJ Vapor Barrier Jacket</td>
</tr>
<tr>
<td>Heat Pump Loop Piping (20 Deg F to 90 deg F)</td>
<td>Indoors 1.5&quot; and larger</td>
<td>1.5-inch fiberglass Insulation with ASJ Vapor Barrier Jacket</td>
</tr>
</tbody>
</table>
3.14 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE

<table>
<thead>
<tr>
<th>System</th>
<th>Pipe Size and Location</th>
<th>Insulation Type and Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat Pump Loop Piping (20 Deg F to 90 deg F) Outdoor, Less than 1.5”</td>
<td>2-inch fiberglass Insulation with ASJ Vapor Barrier Jacket</td>
<td></td>
</tr>
<tr>
<td>Heat Pump Loop Piping (20 Deg F to 90 deg F) Outdoors 1.5” and larger</td>
<td>2-inch fiberglass Insulation with ASJ Vapor Barrier Jacket</td>
<td></td>
</tr>
</tbody>
</table>

3.15 INDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Piping, Concealed:
   1. None.

D. Piping, Exposed:
   1. PVC: 20 mils-thick paintable.

3.16 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Piping, Concealed:
   1. Aluminum, Corrugated: 0.024 inch thick.

D. Piping, Exposed:
   1. Aluminum, Corrugated: 0.024 inch thick.

3.17 UNDERGROUND, FIELD-INSTALLED INSULATION JACKET

A. For underground direct-buried piping applications, install underground direct-buried jacket over insulation material.

END OF SECTION 23 07 19

HVAC PIPING INSULATION
SECTION 23 08 00 - COMMISSIONING OF HVAC SYSTEMS

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.
   B. The OPR and BOD documentation are included by reference for information only.
   C. Division 01 section ‘LEED Requirements’ for additional LEED requirements.

1.2 SUMMARY
   A. This section includes commissioning process requirements for HVAC&R systems, assemblies, and equipment.
   B. Related Sections:
      1. Division 01 Section 01 91 13 “General Commissioning Requirements” for general commissioning process requirements.

1.3 DESCRIPTION
   A. Refer to Division 01 Section 01 91 13 “General Commissioning Requirements” for the description of commissioning.

1.4 DEFINITIONS
   A. Refer to Division 01 Section 01 91 13 “General Commissioning Requirements” for definitions.

1.5 SUBMITTALS
   A. Refer to Division 01 Section 01 91 13 “General Commissioning Requirements” for CxA’s role.
   B. Refer to Division 01 Section “Submittals” for specific requirements.
   C. In addition, provide the following:
      1. Certificates of readiness
      2. Certificates of completion of installation, prestart, and startup activities.
      3. O&M manuals
      4. Test reports
   D. Control Drawings Submittal
      1. The control drawings shall have a key to all abbreviations.
2. The control drawings shall contain graphic schematic depictions of the systems and each component.

3. The schematics will include the system and component layout of any equipment that the control system monitors, enables or controls, even if the equipment is primarily controlled by packaged or integral controls.

4. Provide a full points list with at least the following included for each point:
   a. Controlled system
   b. Point abbreviation
   c. Point description
   d. Display unit
   e. Control point or set point (Yes / No)
   f. Monitoring point (Yes / No)
   g. Intermediate point (Yes / No)
   h. Calculated point (Yes / No)

1.6 QUALITY ASSURANCE

A. Test Equipment Calibration Requirements: Contractors will comply with test manufacturer’s calibration procedures and intervals. Recalibrate test instruments immediately after instruments have been repaired resulting from being dropped or damaged. Affix calibration tags to test instruments. Furnish calibration records to CxA upon request.

1.7 COORDINATION

A. Refer to Division 01 Section “General Commissioning Requirements” for requirements pertaining to coordination during the commissioning process.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. All standard testing equipment required to perform startup, initial checkout and functional performance testing shall be provided by the Contractor for the equipment being tested. For example, the mechanical contractor of Division 23 shall ultimately be responsible for all standard testing equipment for the HVAC&R system and controls system in Division 23, except for equipment specific to and used by TAB in their commissioning responsibilities. A sufficient quantity of two-way radios shall be provided by each subcontractor.

B. Special equipment, tools and instruments (specific to a piece of equipment and only available from vendor) required for testing shall be included in the base bid price to the Owner and left on site, except for stand-alone data logging equipment that may be used by the CxA.

C. Proprietary test equipment and software required by any equipment manufacturer for programming and/or start-up, whether specified or not, shall be provided by the manufacturer of the equipment. Manufacturer shall provide the test equipment, demonstrate its use, and assist in the commissioning process as needed. Proprietary test equipment (and software) shall become the property of the Owner upon completion of the commissioning process.

D. Data logging equipment and software required to test equipment will be provided by the CxA, but shall not become the property of the Owner.
E. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified in the Specifications. If not otherwise noted, the following minimum requirements apply: Temperature sensors and digital thermometers shall have a certified calibration within the past year to an accuracy of 0.5°F and a resolution of + or - 0.1°F. Pressure sensors shall have an accuracy of + or - 2.0% of the value range being measured (not full range of meter) and have been calibrated within the last year.

PART 3 - EXECUTION

3.1 GENERAL DOCUMENTATION REQUIREMENTS

A. With assistance from the installing contractors, the CxA will prepare Pre-Functional Checklists for all commissioned components, equipment, and systems

B. Red-lined Drawings:
   1. The contractor will verify all equipment, systems, instrumentation, wiring and components are shown correctly on red-lined drawings.
   2. Preliminary red-lined drawings must be made available to the Commissioning Team for use prior to the start of Functional Performance Testing.
   3. Changes, as a result of Functional Testing, must be incorporated into the final as-built drawings, which will be created from the red-lined drawings.
   4. The contracted party, as defined in the Contract Documents will create the as-built drawings.

C. Operation and Maintenance Data:
   1. Contractor will provide a copy of O&M literature within 45 days of each submittal acceptance for use during the commissioning process for all commissioned equipment and systems.
   2. The CxA will review the O&M literature once for conformance to project requirements.
   3. The CxA will receive a copy of the final approved O&M literature once corrections have been made by the Contractor.

D. Demonstration and Training:
   1. Contractor will provide demonstration and training as required by the specifications.
   2. A complete training plan and schedule must be submitted by the contractor to the CxA four weeks (4) prior to any training.
   3. A training agenda for each training session must be submitted to the CxA one (1) week prior the training session.
   4. The CxA shall be notified at least 72 hours in advance of scheduled tests so that testing may be observed by the CxA and Owner's representative. A copy of the test record shall be provided to the CxA, Owner, and Architect.
   5. Engage a Factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain specific equipment.
   6. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, trouble shooting, servicing, and maintaining equipment.
   7. Review data in O&M Manuals.
E. Systems manual requirements:

F.  
   1. The Systems Manual is intended to be a usable information resource containing all of the information related to the systems, assemblies, and Commissioning Process in one place with indexes and cross references.

   2. The GC shall include final approved versions of the following information for the Systems Manual:
      a. As-Built System Schematics
      b. Verified Record Drawings
      c. Test Results (not otherwise included in Cx Record)
      d. Periodic Maintenance Information for computer maintenance management system
      e. Recommendations for recalibration frequency of sensors and actuators
      f. A list of contractors, subcontractors, suppliers, architects, and engineers involved in the project along with their contact information
      g. Training Records, Information on training provided, attendees list, and any on-going training

   3. This information shall be organized and arranged by building system, such as fire alarm, chilled water, heating hot water, etc.

   4. Information should be provided in an electronic version to the extent possible. Legible, scanned images are acceptable for non-electronic documentation to facilitate this deliverable.

3.2 CONTRACTOR’S RESPONSIBILITIES

A. Mechanical, Controls and TAB Contractors. The commissioning responsibilities applicable to each of the mechanical, controls and TAB contractors of Division 23 are as follows (all references apply to commissioned equipment only):

B. Perform commissioning tests at the direction of the CxA.

C. Attend construction phase controls coordination meetings.

D. Attend testing, adjusting, and balancing review and coordination meetings.

E. Participate in HVAC&R systems, assemblies, equipment, and component maintenance orientation and inspection as directed by the CxA.

F. Provide information requested by the CxA for final commissioning documentation.

G. Include requirements for submittal data, operation and maintenance data, and training in each purchase order or sub-contract written.

H. Prepare preliminary schedule for Mechanical system orientations and inspections, operation and maintenance manual submissions, training sessions, pipe and duct system testing, flushing and cleaning, equipment start-up, testing and balancing and task completion for owner. Distribute preliminary schedule to commissioning team members.

I. Update schedule as required throughout the construction period.

J. During the startup and initial checkout process, execute the related portions of the prefunctional checklists for all commissioned equipment.
K. Assist the CxA in all verification and functional performance tests.

L. Provide measuring instruments and logging devices to record test data, and provide data acquisition equipment to record data for the complete range of testing for the required test period.

M. Gather operation and maintenance literature on all equipment, and assemble in binders as required by the specifications. Submit to CxA (45) days after submittal acceptance.

N. Coordinate with the CxA to provide (48) hour advance notice so that the witnessing of equipment and system start-up and testing can begin.

O. Notify the CxA a minimum of (2) weeks in advance of the time for start of the testing and balancing work. Attend the initial testing and balancing meeting for review of the official testing and balancing procedures.

P. Participate in, and schedule vendors and contractors to participate in the training sessions.

Q. Provide written notification to the CM/GC and CxA Authority that the following work has been completed in accordance with the contract documents, and that the equipment, systems, and sub-system are operating as required.
   1. HVAC&R equipment including all fans, air handling units, ductwork, dampers, terminals, and all other equipment furnished under this Division.
   2. Fire stopping in the fire rated construction, including fire and smoke damper installation, caulking, gasketing and sealing of smoke barriers.
   3. Fire detection and smoke detection devices furnished under other divisions of the specification.

R. The equipment supplier shall document the performance of his equipment.

S. Provide a complete set of red-lined drawings to the CxA prior to the start of Functional Performance Testing.

T. Test, Adjust and Balance Contractor
   1. Attend initial commissioning coordination meeting scheduled by the Commissioning Authority.
   2. Submit the site specific testing and balancing plan to the CxA and AE for review and acceptance.
   3. Attend the testing and balancing review meeting scheduled by the CxA. Be prepared to discuss the procedures that shall be followed in testing, adjusting, and balancing the HVAC&R system.
   4. At the completion of the testing and balancing work, and the submittal of the final testing and balancing report, notify the HVAC&R contractor and the CM/GC.
   5. At the completion of testing and balancing work, and the submittal of the final testing and balancing report, notify the HVAC&R Contractor and the CM/GC.
   6. Participate in verification of the testing and balancing report, which will consist of repeating measurements contained in the testing and balancing reports. Assist in diagnostic purposes when directed.

U. Provide training of the Owner’s operating staff using expert qualified personnel, as specified.

V. Equipment Suppliers
   1. Provide all requested submittal data, including detailed start-up procedures and specific responsibilities of the Owner, to keep warranties in force.
   2. Assist in equipment testing per agreements with contractors.
   3. Provide information requested by CxA regarding equipment sequence of operation and testing procedures.
W. Refer to Division 01 Section 01 91 13 “General Commissioning Requirements” for additional contractor responsibilities.

### 3.3 OWNER’S RESPONSIBILITIES

A. Refer to Division 01 Section 01 91 13 “General Commissioning Requirements” for Owner’s Responsibilities.

### 3.4 DESIGN PROFESSIONAL’S RESPONSIBILITIES

A. Refer to Division 01 Section 01 91 13 “General Commissioning Requirements” for Design Professional’s Responsibilities.

### 3.5 CxA’S RESPONSIBILITIES

A. Refer to Division 01 Section 01 91 13 “General Commissioning Requirements” for CxA’s Responsibilities.

### 3.6 TESTING PREPARATION

A. Certify in writing to the CxA that HVAC&R systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.

B. Certify in writing to the CxA that HVAC&R instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents, and that pretest set points have been recorded.

C. Certify in writing that testing, adjusting, and balancing procedures have been completed and that testing, adjusting, and balancing reports have been submitted, discrepancies corrected, and corrective work approved.

D. Place systems, subsystems, and equipment into operating mode to be tested (e.g., normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).

E. Inspect and verify the position of each device and interlock identified on checklists.

F. Check safety cutouts, alarms, and interlocks with smoke control and life-safety systems during each mode of operation.

G. Testing Instrumentation: Install measuring instruments and logging devices to record test data as directed by the CxA.

### 3.7 TESTING, ADJUSTING AND BALANCING VERIFICATION

A. Prior to performance of Testing, Adjusting and Balancing work, provide copies of reports, sample forms, checklists, and certificates to the CxA.
B. Notify the CxA at least ten (10) days in advance of testing and balancing Work, and provide access for the CxA to witness testing and balancing Work.

C. Provide technicians, instrumentation, and tools to verify testing and balancing of HVAC&R systems at the direction of the CxA.

1. The CxA will notify testing and balancing subcontractor ten (10) days in advance of the date of field verification. Notice will not include data points to be verified.
2. The testing and balancing subcontractor shall use the same instruments (by model and serial number) that were used when original data were collected.
3. Failure of an item includes, other than sound, a deviation of more than 10 percent. Failure of more than 10 percent of selected items shall result in rejection of final testing, adjusting, and balancing report. For sound pressure readings, a deviation of 3 dB shall result in rejection of final testing. Variations in background noise must be considered.
4. Remedy the deficiency and notify the CxA so verification of failed portions can be performed.

3.8 GENERAL TESTING REQUIREMENTS

A. Provide technicians, instrumentation, and tools to perform commissioning test at the direction of the CxA.

B. Scope of HVAC&R testing shall include entire HVAC&R installation, from central equipment for heat generation and refrigeration through distribution systems to each conditioned space. Testing shall include measuring capacities and effectiveness of operational and control functions.

C. Test all operating modes, interlocks, control responses, and responses to abnormal or emergency conditions, and verify proper response of building automation system controllers and sensors.

D. The CxA along with the HVAC&R contractor, testing and balancing Subcontractor, and HVAC&R Instrumentation and Control Subcontractor shall prepare detailed testing plans, procedures, and checklists for HVAC&R systems, subsystems, and equipment.

E. Tests will be performed using design conditions whenever possible.

F. Simulated conditions may need to be imposed using an artificial load when it is not practical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by the CxA and document simulated conditions and methods of simulation. After tests, return settings to normal operating conditions.

G. The CxA may direct that set points be altered when simulating conditions is not practical.

H. The CxA may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are not practical.

I. If tests cannot be completed because of a deficiency outside the scope of the HVAC&R system, document the deficiency and report it to the Owner. After deficiencies are resolved, reschedule tests.

J. If the testing plan indicates specific seasonal testing, complete appropriate initial performance tests and documentation and schedule seasonal tests.
3.9 HVAC&R SYSTEMS, SUBSYSTEMS, AND EQUIPMENT TESTING PROCEDURES

A. Equipment Testing and Acceptance Procedures: Testing requirements are specified in individual Division 23 sections. Provide submittals, test data, inspector record, and certifications to the CxA.

B. HVAC&R Instrumentation and Control System Testing: Field testing plans and testing requirements are specified in Division 23 Section 23 09 93 “Instrumentation and Control for HVAC” and “Sequence of Operations for HVAC Controls.” Assist the CxA with preparation of testing plans.

C. Pipe system cleaning, flushing, hydrostatic tests, and chemical treatment: Test requirements are specified in Division 23 piping Sections. HVAC&R Contractor shall prepare a pipe system cleaning, flushing, and hydrostatic testing plan. Provide cleaning, flushing, testing, and treating plan and final reports to the CxA. Plan shall include the following:

1. Sequence of testing and testing procedures for each section of pipe to be tested, identified by pipe zone or sector identification marker. Markers shall be keyed to Drawings for each pipe sector, showing the physical location of each designated pipe test section. Drawings keyed to pipe zones or sectors shall be formatted to allow each section of piping to be physically located and identified when referred to in pipe system cleaning, flushing, hydrostatic testing, and chemical treatment plan.
2. Description of equipment for flushing operations.
4. Tracking checklist for managing and ensuring that all pipe sections have been cleaned, flushed, hydrostatically tested, and chemically treated.

D. Refrigeration System Testing: Provide technicians, instrumentation, tools, and equipment to test performance of chillers, cooling towers, refrigerant compressors and condensers, heat pumps, and other refrigeration systems. The CxA shall determine the sequence of testing and testing procedures for each equipment item and pipe section to be tested.

E. HVAC&R Distribution System Testing: Provide technicians, instrumentation, tools, and equipment to test performance of air, steam, and hydronic distribution systems; special exhaust; and other distribution systems, including HVAC&R terminal equipment and unitary equipment.

F. The work included in the commissioning process involves a complete and thorough evaluation of the operation and performance of all components, systems and sub-systems. The following equipment and systems shall be evaluated:

1. Steam Heat Exchangers
2. Pumps/Piping Systems
3. Air Handling Unit – Ventilation
4. DOAS Unit – Ventilation
5. ERV Unit – Inspiration Hall
6. Heat Pumps
7. Building Automation System (see below)
8. Cabinet Unit Heater
9. Geothermal Pumping
10. Solar Wall
11. Panel Radiators
12. Ventilation/Exhaust VAV
13. Exhaust Fans
14. Fire and Smoke Damper
15. Gycol Make-up System
16. Verification of Testing, Adjusting and Balancing
17. VFD
3.10 DEFICIENCIES/NON-CONFORMANCE, COST OF RETESTING, FAILURE DUE TO MANUFACTURER DEFECT

A. Refer to Division 01 Section 01 91 13 “General Commissioning Requirements” for requirements pertaining to deficiencies/non-conformance, cost of retesting, or failure due to manufacturer defect.

3.11 APPROVAL

A. Refer to Division 01 Section 01 91 13 “General Commissioning Requirements” for approval procedures.

3.12 DEFERRED TESTING

A. Refer to Division 01 Section “General Commissioning Requirements” for requirements pertaining to deferred testing.

3.13 OPERATION AND MAINTENANCE MANUALS

A. The Operation and Maintenance Manuals shall conform to Contract Documents requirements as stated in Division 01.

B. Refer to Division 01 Section 01 91 13 “General Commissioning Requirements” for the AE and CxA roles in the Operation and Maintenance Manual contribution, review and approval process.

C. An updated as-built version of the control drawings and sequences of operation shall be included in the final controls O&M manual submittal.

3.14 TRAINING OF OWNER PERSONNEL

A. Refer to Division 01 Section 01 91 13 “General Commissioning Requirements” for requirements pertaining to training.

B. All training will be performed in duplicate for two separate sets of trade groups.

C. Mechanical Contractor. The mechanical contractor shall have the following training responsibilities:

1. Provide the CxA with a training plan two weeks before the planned training.

2. Provide designated Owner personnel with comprehensive orientation and training in the understanding of the systems and the operation and maintenance of each piece of HVAC equipment including, but not limited to, all HVAC equipment (ex. pumps, heat exchangers, chillers, heat rejection equipment, air conditioning units, air handling units, fans, terminal units, controls and water treatment systems, etc.)

3. Training shall normally start with classroom sessions followed by hands-on training on each piece of equipment, which shall illustrate the various modes of operation, including startup, shutdown, fire/smoke alarm, power failure, etc.

4. During any demonstration, should the system fail to perform in accordance with the requirements of the O&M manual or sequence of operations, the system will be repaired or adjusted as necessary and the demonstration repeated.
5. The appropriate trade or manufacturer's representative shall provide the instructions on each major piece of equipment. This person may be the start-up technician for the piece of equipment, the installing contractor or manufacturer’s representative. Practical building operating expertise as well as in-depth knowledge of all modes of operation of the specific piece of equipment are required. More than one party may be required to execute the training.

6. The controls contractor shall attend sessions other than the controls training, as requested, to discuss the interaction of the controls system as it relates to the equipment being discussed.

7. The training sessions shall follow the outline in the Table of Contents of the operation and maintenance manual and illustrate whenever possible the use of the O&M manuals for reference.

8. Training shall include:
   a. Use of the printed installation, operation and maintenance instruction material included in the O&M manuals.
   b. A review of the written O&M instructions emphasizing safe and proper operating requirements, preventative maintenance, special tools needed and spare parts inventory suggestions. The training shall include start-up, operation in all modes possible, shut-down, seasonal changeover and any emergency procedures.
   c. Discussion of relevant health and safety issues and concerns.
   d. Discussion of warranties and guarantees.
   e. Common troubleshooting problems and solutions.
   f. Explanatory information included in the O&M manuals and the location of all plans and manuals in the facility.
   g. Discussion of any peculiarities of equipment installation or operation.
   h. The format and training agenda in The HVAC Commissioning Process, ASHRAE Guideline 1-2007, is recommended.

9. Hands-on training shall include start-up, operation in all modes possible, including manual, shut-down and any emergency procedures and preventative maintenance for all pieces of equipment.

10. The mechanical contractor shall fully explain and demonstrate the operation, function and overrides of any local packaged controls, not controlled by the central control system.

11. Training shall occur after functional testing is complete, unless approved otherwise by the Owner.

D. Controls Contractor. The controls contractor shall have the following training responsibilities:

1. Provide the CxA and AE with a training plan four weeks before the planned training.

2. The controls contractor shall provide designated Owner personnel training on the control system in this facility. The intent is to clearly and completely instruct the Owner on all the capabilities of the control system.

3. Training manuals. The standard operating manual for the system and any special training manuals will be provided for each trainee, with three extra copies left for the O&M manuals. In addition, copies of the system technical manual will be demonstrated during training and three copies submitted with the O&M manuals. Manuals shall include detailed description of the subject matter for each session. The manuals will cover all control sequences and have a definitions section that fully describes all relevant words used in the manuals and in all software displays. Manuals will be approved by the CxA and AE. Copies of audiovisuals shall be delivered to the Owner.
4. The trainings will be tailored to the needs and skill-level of the trainees.

5. The trainers will be knowledgeable on the system and its use in buildings. For the on-site sessions, the most qualified trainer(s) will be used. The Owner shall approve the instructor prior to scheduling the training.

6. During any demonstration, should the system fail to perform in accordance with the requirements of the O&M manual or sequence of operations, the system will be repaired or adjusted as necessary and the demonstration repeated.

7. The controls contractor shall attend sessions other than the controls training, as requested, to discuss the interaction of the controls system as it relates to the equipment being discussed.

8. There shall be three (3) training sessions:

   a. Training I. Control System. The first training shall consist of 8 hours of actual training. This training may be held on-site or in the supplier's facility. If held off-site, the training may occur prior to final completion of the system installation. Upon completion, each student, using appropriate documentation, should be able to perform elementary operations and describe general hardware architecture and functionality of the system.

   b. Training II. Building Systems. The second session shall be held on-site for a period of 8 hours of actual hands-on training after the completion of system commissioning. The session shall include instruction on:

      1) Specific hardware configuration of installed systems in this building and specific instruction for operating the installed system, including HVAC systems, lighting controls and any interface with security and communication systems.

      2) Security levels, alarms, system start-up, shut-down, power outage and restart routines, changing set points and alarms and other typical changed parameters, overrides, freeze protection, manual operation of equipment, optional control strategies that can be considered, energy savings strategies and set points that if changed will adversely affect energy consumption, energy accounting, procedures for obtaining vendor assistance, etc.

      3) All trending and monitoring features (values, change of state, totalization, etc.), including setting up, executing, downloading, viewing both tabular and graphically and printing trends. Trainees will actually set-up trends in the presence of the trainer.

      4) Every screen shall be completely discussed, allowing time for questions.

      5) Use of keypad or plug-in laptop computer at the zone level.

      6) Use of remote access to the system via phone lines or networks.

      7) Setting up and changing an air terminal unit controller.

      8) Graphics generation

      9) Point database entry and modifications

      10) Understanding DDC field panel operating programming (when applicable)

   c. Training III. The third training will be conducted on-site six months after occupancy and consist of 8 hours of training. The session will be structured to address specific topics that trainees need to discuss and to answer questions concerning operation of the system.

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E. TAB. The TAB contractor shall have the following training responsibilities:

1. TAB shall meet for 4 hours with facility staff after completion of TAB and instruct them on the following:

   a. Go over the final TAB report, explaining the layout and meanings of each data type.
   b. Discuss any outstanding deficient items in control, ducting or design that may affect the proper delivery of air or water.
   c. Identify and discuss any terminal units, duct runs, diffusers, coils, fans and pumps that are close to or are not meeting their design capacity.
   d. Discuss any temporary settings and steps to finalize them for any areas that are not finished.
   e. Other salient information that may be useful for facility operations, relative to TAB.

END OF SECTION 23 08 00
SECTION 23 08 50 - ATRIUM SMOKE CONTROL SYSTEM SPECIAL INSPECTION & COMMISSIONING

PART 1 - GENERAL

1.1 SUMMARY
   A. Section includes special inspection and commissioning requirements for the atrium smoke control system, assemblies, and equipment.

1.2 CONTRACTOR'S RESPONSIBILITIES
   A. Coordinate and perform tests at the direction of the Engineer, Owner or A.H.J.
   B. Provide information requested by the Engineer, Owner or A.H.J. for final commissioning documentation.
   C. Provide measuring instruments and logging devices to record test data, and provide data acquisition equipment to record data for the complete range of testing for the required test period.

1.3 SPECIAL INSPECTION & COMMISSIONING DOCUMENTATION
   A. Provide the following information for inclusion in the commissioning plan:
      1. Plan for delivery and review of submittals, systems manuals, and other documents and reports.
      2. Identification of installed systems, assemblies, equipment, and components including changes that occurred during the construction phase.
      3. Process and schedule for completing construction checklists and manufacturer's prestart and startup checklists for smoke control system, assemblies, equipment, and components to be verified and tested.
      4. Certificate of readiness, signed by the Contractor, certifying that smoke control system, assemblies, equipment, components, and associated controls are ready for testing.
      5. Certificate of completion certifying that installation, prestart checks, and startup procedures have been completed.
      6. Certificate of readiness certifying that smoke control system, subsystems, equipment, and associated controls are ready for testing.
      7. Test and inspection reports and certificates.
      8. Corrective action documents.
      9. Verification of testing, adjusting, and balancing reports.

1.4 SUBMITTALS
   A. Certificates of readiness.
   B. Certificates of completion of installation, prestart, and startup activities.
PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 TESTING PREPARATION

A. Certify that smoke control system, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.

B. Certify that smoke control instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents, and that pretest set points have been recorded.

C. Certify that testing, adjusting, and balancing procedures have been completed and that testing, adjusting, and balancing reports have been submitted, discrepancies corrected, and corrective work approved.

D. Set systems, subsystems, and equipment into operating mode to be tested (e.g., normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).

E. Inspect and verify the position of each device and interlock identified on checklists.

F. Check safety cutouts, alarms, and interlocks with smoke control and life-safety systems during each mode of operation.

G. Testing Instrumentation: Install measuring instruments and logging devices to record test data as required for proper testing.

3.2 TESTING AND BALANCING VERIFICATION

A. Prior to performance of testing and balancing Work, provide copies of reports, sample forms, checklists, to the Engineer.

B. Notify the Engineer at least 10 days in advance of testing and balancing Work, and provide access for the Owner, Engineer, and A.H.J. to witness testing and balancing Work.

C. Provide technicians, instrumentation, and tools to verify testing and balancing of smoke control system.

1. The testing and balancing Contractor shall use the same instruments (by model and serial number) that were used when original data were collected.

2. Failure of an item includes, other than sound, a deviation of more than 10 percent. Failure of more than 10 percent of selected items shall result in rejection of final testing, adjusting, and balancing report. Remedy the deficiency and notify the Architect so verification of failed portions can be performed.

3.3 GENERAL TESTING REQUIREMENTS

A. Provide technicians, instrumentation, and tools to perform commissioning test at the direction of the Engineer.
B. The HVAC&R Contractor, testing and balancing Contractor, temperature control/BMS contractor, and Fire Alarm Contractor shall prepare detailed testing plans, procedures, and checklists for the Atrium smoke control systems, subsystems, and equipment.

C. If tests cannot be completed because of a deficiency outside the scope of the HVAC system, document the deficiency and report it to the Owner. After deficiencies are resolved, reschedule tests.

3.4 SMOKE CONTROL SYSTEM REQUIREMENTS

A. The 2012 International Building Code requires special inspections of smoke controls systems. The requirements are as follows:

1. During erection of ductwork and prior to concealment for the purpose of leak testing and recording of device location. Pressure and leak test smoke exhaust to 1.5 times the operating pressure. Leakage shall not exceed code maximum.
2. Prior to occupancy and after sufficient completion for the purposes of pressure differential testing, flow measurements and detection and control verification. The inspection plan developed is largely taken from NFPA 92B

3.5 INSPECTION PLAN

A. During the erection of the ductwork, the ductwork will be inspected for the purposes of determining excessive leakage. The various intake units and exhaust fans will be reviewed for proper installation. At the completion of the project and prior to occupancy, acceptance testing will be conducted on the various and related systems including fire alarm system, emergency generator/automatic transfer switch system, and fire sprinkler system. After these systems have been accepted, the smoke management function will be checked.

3.6 TESTING

A. Each system will be tested against its specific design criteria. The test procedures described herein are divided into two categories:

1. Component system testing.
2. Acceptance testing.

3.7 COMPONENT SYSTEM TESTING

A. General. The intent of component system testing is to establish that the final installation complies with the specified design, is functioning properly, and is ready for acceptance testing. Acceptance testing is required of the installing contractor.

B. Prior to testing, the contractors will verify completeness of building construction, including the following architectural features:

1. Integrity of any partition, floor, or other member intended to resist smoke passage.
2. Firestopping.
3. Doors and closers related to smoke control.
4. Glazing that encloses a large-volume space.
C. The operational testing of each individual system component will be performed as it is completed during construction. These operational tests will normally be performed by various trades before interconnection is made to integrate the overall smoke management system. It will be documented in writing that each individual system component installation is complete and the component is functional. Each component test should be individually documented, including such items as speed, volume, sensitivity calibration, voltage, and amperage.

D. Testing should include the following subsystems to the extent that they affect or are affected by the operation of the smoke management system:

1. Fire protective signaling system (See NFPA 72, National fire alarm code).
2. Energy management system.
3. Building management system.
4. HVAC equipment.
5. Electrical equipment.
6. Temperature control system.
7. Power sources.
8. Standby power.
9. Automatic suppression systems.
10. Automatic operating doors and automatic operating windows and closures.
11. Other smoke-control systems.

3.8 ACCEPTANCE TESTING

A. The intent of acceptance testing is to demonstrate that the final integrated system installation complies with the specific design and is functioning properly. Representatives of the following will be present to grant acceptance:

1. Authority having jurisdiction.
2. Owner.
3. Engineer.

B. Test parameters need to be measured during acceptance testing:

1. Total volumetric flow rate.
2. Airflow velocities.
3. Airflow direction.
4. Door-opening forces.
5. Pressure differentials.

C. Test Equipment, the following equipment will be needed to perform acceptance testing:

1. Differential pressure gauges, inclined water manometers, or electronic manometer (instrument ranges 0 - 0.25 in w.g. (9 - 62.5 pa) and 0 - 0.50 in w.g. (0 - 125 pa) with 50 ft (15.2 m) of tubing.
2. Scale suitable for measuring door-opening force.
3. Anemometer, including traversing equipment.
4. Ammeter.
5. Door wedges.
6. Tissue paper roll or other convenient device for indicating direction of airflow.
7. Signs indicating that a test of the smoke management system is in progress and that doors should not be opened.
8. Several walkie-talkie radios to help coordinate equipment operation and data records.
9. Smoke generator.
D. Testing procedure. The acceptance testing should consider inclusion of the procedures described in 5-3.4.1 through 5-3.4.6.

1. Prior to beginning acceptance testing, all building equipment will be placed in the normal operating mode, including equipment that is not used to implement smoke management, such as toilet exhaust, central station A.H.U. and similar systems.

2. Wind speed, direction, and outside temperature will be recorded for each test day. If conditions change greatly during the testing, new conditions should be recorded.

3. The acceptance testing will be conducted while on both normal and standby power. Disconnect the normal building power at the main service disconnect to simulate true operating conditions in this mode.

4. The acceptance testing will include demonstrating that the correct outputs are produced for a given input for each control sequence specified. Consideration will be given to the following control sequences so that the complete smoke management sequence is demonstrated:
   a. Normal Mode.
   b. Automatic smoke management mode for first alarm.
   d. Return to normal.

5. It is acceptable to perform tests for the fire protective signaling system in conjunction with the smoke management system. One or more device circuits on the fire protective signaling system can initiate a single input signal to the smoke management system. Therefore, consideration will be given to establishing the appropriate number of initiating devices and initiating device circuits to be operated to demonstrate the smoke management system operation.

6. Much can be accomplished to demonstrate smoke management system operation without resorting to demonstrations that use smoke or products that simulate smoke.

3.9 LARGE VOLUME SPACE SMOKE MANAGEMENT SYSTEMS

A. With the HVAC systems in their normal mode, measure pressure differences across all door barriers and airflow velocities at interfaces with open areas. Using the scale, measure the force necessary to open each door.

B. Activate the smoke management system. Verify and record the operation of all fans, dampers, doors, and related equipment. Measure fan exhaust capacities, air velocities through inlet doors and grilles of the mechanical makeup air system. Measure the force to open exit doors.

C. Measure and record the pressure difference across all doors that separate the smoke management system area from adjacent spaces and the velocities at interfaces with open areas.

3.10 OTHER TEST METHODS

A. General. The test methods previously described should provide an adequate means to evaluate the smoke management systems performance. Other test methods have been used historically in instances where the Authority Having Jurisdiction requires additional testing. These test methods have limited value in evaluating certain system performance, and their validity as a method of testing a smoke management system is questionable.

B. The dynamics of the fire plume, buoyancy forces, and stratification are all major critical elements in the design of the smoke management system. Therefore, to test the system properly, a real fire condition would be the most appropriate and meaningful test. But there are many valid reasons why such a fire is
usually to practical in a completed building. Open flame/actual fire testing might be dangerous and should not normally be attempted. Any other test is a compromise. If a test of the smoke management system for building acceptance is mandated by the Authority Having Jurisdiction, such a test condition would become the basis of design and might not in any way simulate any real fire condition. More importantly, it could be a deception and provide a false sense of security that the smoke management system would perform adequately in a real fire emergency.

C. Smoke bomb tests do not provide the heat, buoyancy, and entrainment of a real fire and are not useful to evaluate the real performance of the system. A system designed in accordance with this document and capable of providing the intended smoke management might not pass smoke bomb tests. Conversely, it is possible for a system that is incapable of providing the intended smoke management to pass smoke bomb tests. Because of the impracticality of conducting real fire tests, the acceptance tests described in this document are directed to those aspects of smoke management systems that can be verified.

3.11 TEST DOCUMENTATION

A. Upon completion of acceptance testing, a copy of all operational testing documentation will be provided to the Engineer of record for approval. Once approved, the report shall be submitted to the Owner. This documentation should be available for reference for periodic testing and maintenance.

B. Test documentation shall include:

1. Test procedures and results.
2. Test and balance data including flows and design valves.
3. Manufacturer, nameplate data, identification tag data for each smoke controls component.
4. Charts/drawings and plans locating the smoke control components.
5. AHJ approval signature.
PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. System will be installed and provided by the TC contractor.

1.2 OVERVIEW

A. This document contains the specification and input/output summaries for a Air Quality Monitoring System (LMS). The system architecture shall utilize local room sensors, duct and outside air probes networked to distributed Air Data Routers and Sensors Suites communicating over a data and air sampling network. The air sampling network shall consist of an air packet transportation network that shall transport air samples from the environment being monitored to distributed Sensor Suites located throughout the facility. The air sampling network shall consist of intelligent air packet routers, an electrically conductive micro duct network, and structured cable. Gathering of air samples shall occur via room, duct mounted, and outside air sampling sensors and probes located as indicated in the documents. The LMS shall provide continuous monitoring of environmental conditions as prescribed in the Sensor Suite section, and provide protected access via a web based user interface to analytical summaries in onscreen and report form. The LMS shall interface with other analog and microprocessor based building subsystems as shown on the drawings, specified herein and in other sections.

1.3 RELATED SECTIONS

A. 3rd-Party Interfacing is required on this project according to the following Specification sections for sub-systems:

1. Section 23 09 00 – Building Automation System

B. REFERENCES

1. ANSI/ASHRAE 135-2001: BACnet™ - A Data Communication Protocol for Building Automation Systems: This shall include the Standard and all published Addenda.

1.4 DEFINITIONS

A. BMS refers to the Building Management System (DDC Controls System).

B. LMS refers to the hardware, software and other components comprising the Laboratory Monitoring System as herein described.

C. I/O refers to Input/Output. Thus, "I/O device" means "Input/Output device".
1.5 ACCEPTABLE FACILITY MONITORING SYSTEM CONTRACTOR (FMC)

A. The Laboratory Monitoring System shall be by Aircuity, Inc.

PART 2 - SCOPE OF WORK

2.1 CONTRACTOR RESPONSIBILITIES:

A. The LMS provider shall furnish all necessary hardware, wiring, structured cable, tubing, computing equipment and software required to provide a complete and functional system necessary to perform the design intent and as defined in this specification.

B. Installation of all LMS components; and all electrical work required as an integral part of this section as noted in Part 5.0 Execution including but not limited to Sensor Suites, Air Data Routers, Room Sensors, Duct Probes, Transformers, Vacuum Pumps, Information Management Servers, Structured Cable, etc., shall be by 230900

C. A separate proposal shall be furnished to the owner by the LMS provider at the time of the bid noting all annual service costs for the sensors in the Sensor Suite; including sensor element replacement, calibration, warranty, and diagnostic services as specified in paragraph 2.7.

2.2 SYSTEM REQUIREMENTS

A. All material and equipment used shall be standard components, regularly manufactured and available by the manufacturer and not custom designed especially for this project. All systems and components, except site specific software, shall have previously been thoroughly tested and proven in actual use prior to installation on this project.

B. The system architecture shall be fully modular permitting expansion of application software, system peripherals, and field hardware.

C. The system, upon completion of the installation and prior to acceptance of the project, shall perform all operating functions as detailed in this specification.

2.3 EQUIPMENT

A. System Hardware

1. The LMS provider shall provide the following:

   a. All Air Data Routers, Sensor Suites, Sensor Suite Sensors, Room Sensors, Duct Probes, Outside Air Probes Information Management Servers, Vacuum Pumps, Structured Cable, transformers, required to perform the functions listed.

B. System Software

1. The Laboratory Monitoring System provider shall provide all software identified in this specification. The database required for implementation of these specifications shall be provided by the LMS provider, including point descriptors, test sequences, reports and point summaries.
The Laboratory Monitoring System provider shall provide and create the system using the latest software release, at the time of Shop Drawing approval.

C. Codes and Regulations

1. All electrical equipment and material and its installation shall conform to the current requirements of the following authorities:
   a. Occupational Safety and Health Act (OSHA)
   b. National Electric Code (NEC)
   c. National Fire Code

2. All Air Data Routers and Sensor Suites shall be listed per Underwriters Laboratories UL916 for Open Energy Management

3. Where two or more codes conflict, the most restrictive shall apply. Nothing in this specification or related documentation shall be construed to permit work not conforming to applicable codes.

D. The Laboratory Monitoring System provider shall provide all test area attribute data and programming and shall coordinate object naming conventions and network map requirements with the owner’s internal BMS department. The naming convention shall be submitted with the Laboratory Monitoring System provider Shop Drawings for review and approval by owner’s BMS department.

2.4 SUBMITTALS

A. As soon as Submittals are prepared, an electronic version shall be provided simultaneously with the mailing of the paper copies. This version shall be transmitted in electronic format, via e-mail, to expedite the approval process.

B. As-Built Drawings shall be created after the final system checkout, by modifying and adding to the Shop Drawings. As-Built Drawings shall show exact installation. As-Built Drawings will be acknowledged in writing by the project design engineer and the owner’s representative after the final checkout of the system. The system will not be considered complete until the As-Built Drawings have received their final approval. The Laboratory Monitoring System provider shall provide four sets of As-Built Drawings.

C. Operating and Maintenance Manuals

1. Operating and Maintenance (O&M) manuals for the system shall include project specific, detailed information describing the specific installation.

2.5 WARRANTY

A. Repair or replace any defective product and correct any defect in material or workmanship for a period of 12 months following the date of acceptance of the system.

PART 3 - PRODUCTS, HARDWARE

3.1 AIR DATA ROUTERS
A. The Air Data Router shall be furnished as a complete, self contained, unit housing all electronics, air solenoid valves, sampling manifolds, firmware, and software. Unit shall be furnished with all internal devices and wiring assembled and tested at the factory.

3.2 SENSOR SUITE

A. The Sensor Suite shall be a distributed, network based, multipoint sensing device. The Sensor Suite shall be furnished as a complete, self contained unit housing all electronics, sensing card cage, sampling manifolds, flow regulators, pressure regulators, firmware, and software.

3.3 INFORMATION MANAGEMENT SERVER

A. The Information Management Server (Server) shall provide network management of Sensor Suites, integration to the BMS, and interface to the building management system (DDC system by TC contractor) for viewing and outputting graphs, charts and data derived from the Facility Monitoring System.

B. The Server shall be located within 25 feet of the nearest Sensor Suite and be connected to the Server through the RS-232 serial port.

3.4 STRUCTURED CABLE

A. The LMS shall utilize a pre-engineered system of Structured Cable to facilitate network wide communications; distribution of low voltage power to Air Data Routers and Sensor Suites; and provide a sampling conduit for air samples all within a single cable.

B. Structured cable shall meet the requirements for use in a plenum (ASTM E84 - flame spread less than 25 and smoke spread less than 50)

PART 4 - PRODUCTS, SOFTWARE

4.1 SYSTEM SOFTWARE OVERVIEW

A. The Laboratory Monitoring System provider shall provide all software required for operation of the LMS system specified herein. All functionality described herein shall be regarded as a

4.2 USER INTERFACE AND DATA MANAGEMENT SYSTEM

A. Included with the system shall be an interface to the building management system (BMS). The connection shall be BacNet native or provided with a BacNet gateway. Fully integrate the system to the BacNet BMS system to allow for viewing and use of data. The data management system shall be password protected and shall be able to store sampled data from all test areas for online viewing and reporting.

B. Unlimited data access, viewing, report generation and remote data storage shall be provided with the LMS for the duration of the project commissioning and for the entire warranty period.
PART 5 - EXECUTION

5.1 GENERAL

A. Verify that systems are complete and ensure that the systems are capable of being started and operated in a safe and normal condition before attempting to operate the LMS.

B. Install software in Air Data Routers, Sensor Suites and Server. Implement all features of programs to specified requirements and as appropriate for sequence of operation.

C. Connect and configure equipment and software to achieve sequence of operation specified.

5.2 TRAINING

A. The Laboratory Monitoring System provider shall provide factory-trained instructor to give full instructions to designated personnel in the operation, maintenance, and programming of the system. Instructors shall be thoroughly familiar with all aspects of the subject matter they are to teach. The training shall be specifically oriented to the system and interfacing equipment installed.

5.3 SEQUENCE OF OPERATIONS

A. Shop Minimum Ventilation Dynamic Reset (Shop-DCV):

1. The DDC system shall control the airflow via heat pumps and in response to the greatest of three demands: 1) temperature control, 2) Minimum Ventilation. Reference 230993 for additional information regarding the sequence of operations.

2. The Shop Monitoring System will provide proportional, analog, minimum ventilation reset signals that correspond to the Total Volatile Organic Compounds (TVOCs), small particles (PM2.5), and carbon dioxide (CO2) concentrations sensed within the General Exhaust duct for each lab. The minimum ventilation reset signal for each lab will be sent to its corresponding lab zone controller to dynamically reset the minimum ventilation rate (air changes per hour). The actual lab ACH shall be dynamic and equal to the higher of the temperature control demand, and as required to maintain air quality.

5.4 FACILITY MONITORING SYSTEM INTERFACE

A. The building shall be equipped with a Facility Monitoring and Control System (LMS) as specified in other sections of these specifications. The purpose of the system is to analyze key elements of the indoor environment and to provide direction to the mechanical systems via the BMS. Directions to be achieved shall be accomplished by monitoring and analysis of airborne parameters such as particulates, volatile organic compounds (VOCs), moisture content, gases such as carbon monoxide and carbon dioxide (CO, CO2), and others as indicated in the LMS specification.

B. BMS CONTRACTOR’S RESPONSIBILITY: The BMS contractor shall be required to connect the BMS to LMS which shall communicate with the BMS via BACnet. All communication shall be from the LMS to the BMS. The BMS contractor shall be responsible for:

1. Entering the LMS in the BMS so it is a recognized component in the BMS.
2. Entering the necessary data points in the BMS data base. These data points will serve as data values to be used as set points in the building control systems for values such as minimum
outside air levels, overall ventilation rates, humidity levels, and others as indicated in the specification or on the drawings.

3. Implementing the necessary control sequences to respond to the directions from the LMS. These directions will be integrated from a priority standpoint so that other control actions such as smoke control are not impeded.

4. Provide qualified on-site staff during start up of the LMS to insure that communication is functional, that data values are received from the LMS, and that control sequences as a result of this data are implemented properly and effectively.

5.5 STARTUP

A. Provide manufacturer startup technician to verify installation, and initiat and program system, and verify DDC interface is working properly.

B. System will be installed and provided by the TC contractor.

END OF SECTION 23 09 01
SECTION 23 09 23 - DIRECT DIGITAL CONTROL (DDC) SYSTEM FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. DDC system for monitoring and controlling of HVAC systems.
   2. Delivery of selected control devices to equipment and systems manufacturers for factory installation and to HVAC systems installers for field installation.

B. Related Requirements:
   1. Section 23 09 93 "Sequence of Operations for HVAC Controls" for control sequences in DDC systems.
   2. Section 23 08 00"Commissioning of Mechanical and Control Systems".

1.2 DEFINITIONS

A. Algorithm: A logical procedure for solving a recurrent mathematical problem. A prescribed set of well-defined rules or processes for solving a problem in a finite number of steps.

B. Analog: A continuously varying signal value, such as current, flow, pressure, or temperature.

C. BACnet Specific Definitions:
   2. BACnet Interoperability Building Blocks (BIBBs): BIBB defines a small portion of BACnet functionality that is needed to perform a particular task. BIBBs are combined to build the BACnet functional requirements for a device.
   3. BACnet/IP: Defines and allows using a reserved UDP socket to transmit BACnet messages over IP networks. A BACnet/IP network is a collection of one or more IP subnetworks that share the same BACnet network number.
   5. PICS (Protocol Implementation Conformance Statement): Written document that identifies the particular options specified by BACnet that are implemented in a device.

D. Binary: Two-state signal where a high signal level represents "ON" or "OPEN" condition and a low signal level represents "OFF" or "CLOSED" condition. "Digital" is sometimes used interchangeably with "Binary" to indicate a two-state signal.

E. Controller: Generic term for any standalone, microprocessor-based, digital controller residing on a network, used for local or global control. Three types of controllers are indicated: Network Controller, Programmable Application Controller, and Application-Specific Controller.

F. Control System Integrator: An entity that assists in expansion of existing enterprise system and support of additional operator interfaces to I/O being added to existing enterprise system.
G. COV: Changes of value.

H. DDC System Provider: Authorized representative of, and trained by, DDC system manufacturer and responsible for execution of DDC system Work indicated.

I. Distributed Control: Processing of system data is decentralized and control decisions are made at subsystem level. System operational programs and information are provided to remote subsystems and status is reported back. On loss of communication, subsystems shall be capable of operating in a standalone mode using the last best available data.

J. DOCSIS: Data-OverCable Service Interface Specifications.

K. Gateway: Bidirectional protocol translator that connects control systems that use different communication protocols.

L. HLC: Heavy load conditions.

M. I/O: System through which information is received and transmitted. I/O refers to analog input (AI), binary input (BI), analog output (AO) and binary output (BO). Analog signals are continuous and represent control influences such as flow, level, moisture, pressure, and temperature. Binary signals convert electronic signals to digital pulses (values) and generally represent two-position operating and alarm status. "Digital," (DI and (DO), is sometimes used interchangeably with "Binary," (BI) and (BO), respectively.

N. LAN: Local area network.

O. 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.


Q. MS/TP: Master-slave/token-passing, IEE 8802-3. Datalink protocol LAN option that uses twisted-pair wire for low-speed communication.

R. Network Controller: Digital controller, which supports a family of programmable application controllers and application-specific controllers, that communicates on peer-to-peer network for transmission of global data.

S. Network Repeater: Device that receives data packet from one network and rebroadcasts it to another network. No routing information is added to protocol.

T. PDA: Personal digital assistant.

U. Peer to Peer: Networking architecture that treats all network stations as equal partners.

V. POT: Portable operator's terminal.

W. RAM: Random access memory.

X. RF: Radio frequency.

Y. Router: Device connecting two or more networks at network layer.

Z. TCP/IP: Transport control protocol/Internet protocol incorporated into Microsoft Windows.
AA. UPS: Uninterruptible power supply.

BB. USB: Universal Serial Bus.

CC. User Datagram Protocol (UDP): This protocol assumes that the IP is used as the underlying protocol.

DD. VAV: Variable air volume.

EE. WLED: White light emitting diode.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at project site.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product include the following:

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.

2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.


4. Installation, operation and maintenance instructions including factors effecting performance.

5. Bill of materials of indicating quantity, manufacturer, and extended model number for each unique product.

   a. DDC controllers.
   b. Enclosures.
   c. Electrical power devices.
   d. UPS units.
   e. Accessories.
   f. Instruments.
   g. Control dampers and actuators.
   h. Control valves and actuators.
   i. Any other applicable components.

6. When manufacturer's product datasheets apply to a product series rather than a specific product model, clearly indicate and highlight only applicable information.

7. Each submitted piece of product literature shall clearly cross reference specification and drawings that submittal is to cover.

B. LEED Submittals:

1. Include supporting data showing energy, flow, gas, moisture, motion, pressure, and temperature instruments, where and if used in Project; and associated application for monitoring and control to satisfy requirements of Project LEED credits.
a. Indicate applicable locations and area coverage, control set points, description of control operation and other required information to satisfy submission requirements for award of LEED credit.

2. Organize and identify standalone, supporting data for each LEED credit.

C. Shop Drawings:

1. Include plans, elevations, sections, and mounting details where applicable.
2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Detail means of vibration isolation and show attachments to rotating equipment.
4. Plan Drawings indicating the following:
   a. Screened backgrounds of walls, structural grid lines, HVAC equipment, ductwork and piping.
   b. Room names and numbers with coordinated placement to avoid interference with control products indicated.
   c. Each desktop operator workstation, server, gateway, router, DDC controller, control panel instrument connecting to DDC controller, and damper and valve connecting to DDC controller, if included in Project.
   d. Exact placement of products in rooms, ducts, and piping to reflect proposed installed condition.
   e. Network communication cable and raceway routing.
   f. Information shall be drawn to an appropriate scale.
   g. Proposed routing of wiring, cabling, conduit, and tubing, coordinated with building services for review before installation.

5. Schematic drawings for each controlled HVAC system indicating the following:
   a. I/O points labeled with point names shown. Indicate instrument range, normal operating set points, and alarm set points. Indicate fail position of each damper and valve, if included in Project.
   b. I/O listed in table format showing point name, type of device, manufacturer, model number, and cross-reference to product data sheet number.
   c. A graphic showing location of control I/O in proper relationship to HVAC system.
   d. Wiring diagram with each I/O point having a unique identification and indicating labels for all wiring terminals.
   e. Unique identification of each I/O that shall be consistently used between different drawings showing same point.
   f. Elementary wiring diagrams of controls for HVAC equipment motor circuits including interlocks, switches, relays and interface to DDC controllers.
   g. Narrative sequence of operation.
   h. Graphic sequence of operation, showing all inputs and output logical blocks.

6. Control panel drawings indicating the following:
   a. Panel dimensions, materials, size, and location of field cable, raceways, and tubing connections.
   b. Interior subpanel layout, drawn to scale and showing all internal components, cabling and wiring raceways, nameplates and allocated spare space.
   c. Front, rear, and side elevations and nameplate legend.
   d. Unique drawing for each panel.

7. DDC system network riser diagram indicating the following:
a. Each device connected to network with unique identification for each.
b. Interconnection of each different network in DDC system.
c. For each network, indicate communication protocol, speed and physical means of interconnecting network devices, such as copper cable type, or fiber-optic cable type. Indicate raceway type and size for each.
d. Each network port for connection of an operator workstation or other type of operator interface with unique identification for each.

8. DDC system electrical power riser diagram indicating the following:
   a. Each point of connection to field power with requirements (volts/phase/hertz/amperes/connection type) listed for each.
   b. Each control power supply including, as applicable, transformers, power-line conditioners, transient voltage suppression and high filter noise units, DC power supplies, and UPS units with unique identification for each.
   c. Each product requiring power with requirements (volts/phase/hertz/amperes/connection type) listed for each.
   d. Power wiring type and size, race type, and size for each.

9. Monitoring and control signal diagrams indicating the following:
   a. Control signal cable and wiring between controllers and I/O.
   b. Point-to-point schematic wiring diagrams for each product.
   c. Control signal tubing to sensors, switches and transmitters.
   d. Process signal tubing to sensors, switches and transmitters.

10. Color graphics indicating the following:
    a. Itemized list of color graphic displays to be provided.
    b. For each display screen to be provided, a true color copy showing layout of pictures, graphics and data displayed.
    c. Intended operator access between related hierarchical display screens.

D. System Description:

1. Full description of DDC system architecture, network configuration, operator interfaces and peripherals, servers, controller types and applications, gateways, routers and other network devices, and power supplies.
2. Complete listing and description of each report, log and trend for format and timing and events which initiate generation.
3. System and product operation under each potential failure condition including, but not limited to, the following:
   a. Loss of power.
   b. Loss of network communication signal.
   c. Loss of controller signals to inputs and outpoints.
   d. Operator workstation failure.
   e. Gateway failure.
   f. Network failure
   g. Controller failure.
   h. Instrument failure.
   i. Control damper and valve actuator failure.
   j. Any other applicable component failure.
4. Complete bibliography of documentation and media to be delivered to Owner.
5. Description of testing plans and procedures.
6. Description of Owner training.

E. Samples:

1. For each exposed product, installed in finished space for approval of selection of aesthetic characteristics.

F. Delegated-Design Submittal: For DDC system products and installation indicated as being delegated.

1. Supporting documentation showing DDC system design complies with performance requirements indicated, including calculations and other documentation necessary to prove compliance.
2. Schedule and design calculations for control dampers and actuators.
   a. Flow at Project design and minimum flow conditions.
   b. Face velocity at Project design and minimum airflow conditions.
   c. Pressure drop across damper at Project design and minimum airflow conditions.
   d. AMCA 500-D damper installation arrangement used to calculate and schedule pressure drop, as applicable to installation.
   e. Maximum close-off pressure.
   f. Leakage airflow at maximum system pressure differential (fan close-off pressure).
   g. Torque required at worst case condition for sizing actuator.
   h. Actuator selection indicating torque provided.
   i. Actuator signal to control damper (on, close or modulate).
   j. Actuator position on loss of power.
   k. Actuator position on loss of control signal.

3. Schedule and design calculations for control valves and actuators.
   a. Flow at Project design and minimum flow conditions.
   b. Pressure-differential drop across valve at Project design flow condition.
   c. Maximum system pressure-differential drop (pump close-off pressure) across valve at Project minimum flow condition.
   d. Design and minimum control valve coefficient with corresponding valve position.
   e. Maximum close-off pressure.
   f. Leakage flow at maximum system pressure differential.
   g. Torque required at worst case condition for sizing actuator.
   h. Actuator selection indicating torque provided.
   i. Actuator signal to control damper (on, close or modulate).
   j. Actuator position on loss of power.
   k. Actuator position on loss of control signal.

4. Schedule and design calculations for selecting flow instruments.
   a. Instrument flow range.
   b. Project design and minimum flow conditions with corresponding accuracy, control signal to transmitter and output signal for remote control.
   c. Extreme points of extended flow range with corresponding accuracy, control signal to transmitter and output signal for remote control.
   d. Pressure-differential loss across instrument at Project design flow conditions.
   e. Where flow sensors are mated with pressure transmitters, provide information for each instrument separately and as an operating pair.
1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plan drawings, reflected ceiling plan(s), and other details, drawn to scale and coordinated with each other, using input from installers of the items involved.

B. Welding certificates.

C. Product Certificates:
   1. Data Communications Protocol Certificates: Certifying that each proposed DDC system component complies with ASHRAE 135.
   2. Any other applicable product certificates.

D. Product Test Reports: For each product that requires testing to be performed by manufacturer and/or a qualified testing agency.

E. Preconstruction Test Reports: For each separate test performed.

F. Source quality-control reports.

G. Field quality-control reports.

H. Sample Warranty: For manufacturer's warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For DDC system to include in emergency, operation and maintenance manuals.
   1. In addition to items specified in Section 01 78 23 "Operation and Maintenance Data," include the following:
      a. Project Record Drawings of as-built versions of submittal Shop Drawings provided in electronic PDF format.
      b. Testing and commissioning reports and checklists of completed final versions of reports, checklists, and trend logs.
      c. As-built versions of submittal Product Data.
      d. Names, addresses, e-mail addresses and 24-hour telephone numbers of Installer and service representatives for DDC system and products.
      e. Operator's manual with procedures for operating control systems including logging on and off, handling alarms, producing point reports, trending data, overriding computer control and changing set points and variables.
      f. Programming manuals with description of programming language and syntax, of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.
      g. Engineering, installation, and maintenance manuals that explain how to:
         1) Design and install new points, panels, and other hardware.
         2) Perform preventive maintenance and calibration.
         3) Debug hardware problems.
         4) Repair or replace hardware.
h. Documentation of all programs created using custom programming language including set points, tuning parameters, and object database.

i. Backup copy of graphic files, programs, and database on electronic media such as DVDs.

j. List of recommended spare parts with part numbers and suppliers.

k. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.

l. Complete original-issue copies of furnished software, including operating systems, custom programming language, operator workstation software, and graphics software.

m. Licenses, guarantees, and warranty documents.

n. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.

o. Owner training materials.

1.7 QUALITY ASSURANCE

A. DDC System Manufacturer Qualifications:

1. Nationally recognized manufacturer of DDC systems and products.

2. DDC systems with similar requirements to those indicated for a continuous period of five years within time of bid.

3. DDC systems and products that have been successfully tested and in use on at least five past projects within the 240 miles of the project site.

4. Having complete published catalog literature, installation, operation and maintenance manuals for all products intended for use.

5. Having full-time in-house employees for the following:

a. Product research and development.

b. Product and application engineering.

c. Product manufacturing, testing and quality control.

d. Technical support for DDC system installation training, commissioning and troubleshooting of installations.

e. Owner operator training.

6. The Manufacturer of the DDC system and products shall provide documentation supporting compliance with ISO-9001 (Model for Quality Assurance in Design/Development, Production, Installation and Servicing). Product literature provided by the FMCS digital controller manufacturer shall contain the ISO-9001 Certification Mark from the applicable registrar.

7. All products used in this installation shall be new, currently under manufacture, and shall be applied in standard off the shelf products. This installation shall not be used as a test site for any new products unless explicitly approved by the Engineer in writing. Spare parts shall be available for at least 5 years after completion of this contract.

B. DDC System Provider Qualifications:

1. Authorized representative of, and trained by, DDC system manufacturer. The Installer shall present for review the certification of completed training, including the hours of instruction and course outlines upon request.

2. At the time of bid, the Installer must have a fully staffed support office located within a 150-mile radius of the project site and must directly employ a minimum of two full-time service technicians (with fully stocked service vans/vehicles) who have been permanently living within 150 miles of the project site for 2 or more years. Installer must be able to provide the owner with 24/7 emergency service within a reasonable time frame.
3. Demonstrated past experience with installation of DDC system products being installed for period within five consecutive years before time of bid.
4. Demonstrated past experience on five projects of similar complexity, scope and value.
5. Each person assigned to Project shall have demonstrated past experience.
6. Staffing resources of competent and experienced full-time employees that are assigned to execute work according to schedule.
7. Service and maintenance staff assigned to support Project during warranty period.
8. Product parts inventory to support on-going DDC system operation for a period of not less than five years after Substantial Completion.
9. The Installer may NOT subcontract out the FCMC installation to another entity that is not an authorized representative of the Manufacturer and/or has not completed the Manufacturer's certified training.

1.8 WARRANTY

A. Manufacturer’s Warranty: Manufacturer and Installer agree to repair or replace products that fail in materials or workmanship within specified warranty period.

1. Failures shall be adjusted, repaired, or replaced at no additional cost or reduction in service to Owner.
2. Include updates or upgrades to software and firmware if necessary to resolve deficiencies.
   a. Install updates only after receiving Owner’s written authorization.

3. Warranty service shall occur during normal business hours and commence within 24 hours of Owner’s warranty service request.
4. Warranty Period: One year from date of Substantial Completion.
5. All programming changes shall be included in one-year warranty. These changes shall be at the Owner’s/Engineer’s discretion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Approved manufacturers and providers:

1. Delta Controls/Siemens Building Technologies/Tridium as provided by Electro Controls (Previously selected based on qualifications)

B. Alternate non-approved installers/manufacturers requesting approval to bid must submit, at least ten (10) working days prior to bid date, a technical prior-approval submittal. The ability of a particular Installer/Manufacturer to install and service equipment and systems will be a consideration in the approval process. This includes proximity and visibility of service in the immediate area. The submission of a technical prior-approval submittal does not guarantee approval to bid. The technical prior-approval submittal shall consist of the following:

1. CAD generated schematic drawings for the entire control system for review and approval. Drawings shall be a one-page diagram depicting the system architecture complete with a communications riser. Drawings shall include point-to-point wiring diagrams and must show: all temperature controls, start-stop arrangement for each piece of equipment, equipment interlocks,
wiring terminal numbers and any special connection information required for properly controlling the mechanical equipment.

2. Bill of material reference list as well as the manufacturer's catalog data describing each item of control equipment or component to be provided and installed on the project.

3. A specification compliance analysis for review and approval. The compliance document shall address each paragraph of the specification and sequence of operations (on plans) by indicating COMPLY, EXCEED, or EXCEPTION. Do not indicate COMPLY unless the proposed system exactly meets the specification requirement. If EXCEED or EXCEPTION is indicated, then provide a clear and concise explanation of the variance from the specifications and the net effect this would have on the specified system performance.

4. A list of references and descriptions of at least five local (Missoula area) installations of the same magnitude at which the Installer/Manufacturer engineered and installed FMCS equipment by the same manufacturer as that proposed for this contract. Include the date of completion and a contact name and telephone number.

2.2 DDC SYSTEM DESCRIPTION

A. Microprocessor-based monitoring and control including analog/digital conversion and program logic. A control loop or subsystem in which digital and analog information is received and processed by a microprocessor, and digital control signals are generated based on control algorithms and transmitted to field devices to achieve a set of predefined conditions.

1. DDC system shall consist of a peer-to-peer network of distributed DDC controllers, other network devices, operator interfaces, and software.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.3 WEB ACCESS

A. DDC system shall be Web based.

1. Web-Based Access to DDC System:

   a. DDC system software shall be based on server thin-client architecture, designed around open standards of Web technology. DDC system server shall be accessed using a Web browser over DDC system network (using Owner's LAN) and/or remotely over Internet (through Owner's LAN or VPN).

   b. Intent of thin-client architecture is to provide operators complete access to DDC system via a Web browser. No special software other than a Web browser shall be required to access graphics, point displays, and trends; to configure trends, points, and controllers; and to edit programming.

   c. Web access shall be password protected.

2.4 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional to design DDC system to satisfy requirements indicated.
1. System Performance Objectives:
   a. DDC system shall manage HVAC systems.
   b. DDC system control shall operate HVAC systems to achieve optimum operating costs while using least possible energy and maintaining specified performance.
   c. DDC system shall respond to power failures, HVAC equipment failures, and adverse and emergency conditions encountered through connected I/O points.
   d. DDC system shall operate while unattended by an operator and through operator interaction.
   e. DDC system shall record trends and transaction of events and produce report information such as performance, energy, occupancies, and equipment operation.

B. Surface-Burning Characteristics: Products installed in ducts, equipment, and return-air paths shall comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
   1. Flame-Spread Index: 25 or less.
   2. Smoke-Developed Index: 50 or less.

C. DDC System Speed:
   1. Response Time of Connected I/O:
      a. AI point values connected to DDC system shall be updated at least every five seconds for use by DDC controllers. Points used globally shall also comply with this requirement.
      b. BI point values connected to DDC system shall be updated at least every five seconds for use by DDC controllers. Points used globally shall also comply with this requirement.
      c. AO points connected to DDC system shall begin to respond to controller output commands within two second(s). Global commands shall also comply with this requirement.
      d. BO point values connected to DDC system shall respond to controller output commands within two second(s). Global commands shall also comply with this requirement.
   2. Display of Connected I/O:
      a. Analog point COV connected to DDC system shall be updated and displayed at least every 20 seconds for use by operator.
      b. Binary point COV connected to DDC system shall be updated and displayed at least every 20 seconds for use by operator.
      c. Alarms of analog and digital points connected to DDC system shall be displayed within 20 seconds of activation or change of state.
      d. Graphic display refresh shall update within 20 seconds.
      e. Point change of values and alarms displayed from workstation to workstation when multiple operators are viewing from multiple workstations shall not exceed graphic refresh rate indicated.

D. Future Expandability:
   1. DDC system size shall be expandable to an ultimate capacity of at least two times total I/O points indicated.
   2. Additional DDC controllers, I/O and associated wiring shall be all that is needed to achieve ultimate capacity. Initial network infrastructure shall be designed and installed to support ultimate capacity.
   3. Operator interfaces installed initially shall not require hardware and software additions and revisions for ultimate capacity.
E. Environmental Conditions for Controllers, Gateways, and Routers:

1. Products shall operate without performance degradation under ambient environmental temperature, pressure and humidity conditions encountered for installed location.
   a. If product alone cannot comply with requirement, install product in a protective enclosure that is isolated and protected from conditions impacting performance. Enclosure shall be internally insulated, electrically heated, cooled and ventilated as required by product and application.

2. Products shall be protected with enclosures satisfying NEMA 250 enclosure standards unless more stringent requirements are indicated. Products not available with integral enclosures complying with these standards shall be housed in protective secondary enclosures satisfying NEMA 250 enclosure standards. Installed location shall dictate the NEMA 250 enclosure requirements:

F. Electric Power Quality:

1. Power-Line Surges:
   a. Protect susceptible DDC system products connected to ac power circuits from power-line surges to comply with requirements of IEEE C62.41.
   b. Do not use fuses for surge protection.
   c. Test protection in the normal mode and in the common mode, using the following two waveforms:
      1) 10-by-1000-mic.sec. waveform with a peak voltage of 1500 V and a peak current of 60 A.
      2) 8-by-20-mic.sec. waveform with a peak voltage of 1000 V and a peak current of 500 A.

2. Power Conditioning:
   a. Protect susceptible DDC system products connected to ac power circuits from irregularities and noise rejection. Characteristics of power-line conditioner shall be as follows:
      1) At 85 percent load, output voltage shall not deviate by more than plus or minus 1 percent of nominal when input voltage fluctuates between minus 20 percent to plus 10 percent of nominal.
      2) During load changes from zero to full load, output voltage shall not deviate by more than plus or minus 3 percent of nominal.
      3) Accomplish full correction of load switching disturbances within five cycles, and 95 percent correction within two cycles of onset of disturbance.
      4) Total harmonic distortion shall not exceed 3-1/2 percent at full load.

3. Ground Fault: Protect products from ground fault by providing suitable grounding. Products shall not fail due to ground fault condition.

G. Backup Power Source:

1. HVAC systems and equipment served by a backup power source shall have associated DDC system products that control such systems and equipment also served from a backup power source.
H. Continuity of Operation after Electric Power Interruption:

1. Equipment and associated factory-installed controls, field-installed controls, electrical equipment, and power supply connected to building normal and backup power systems shall automatically return equipment and associated controls to operating state occurring immediately before loss of normal power, without need for manual intervention by operator when power is restored either through backup power source or through normal power if restored before backup power is brought online.

2.5 SYSTEM ARCHITECTURE

A. System architecture shall consist of no more than three levels of LANs.

1. Level one LAN shall connect network controllers and operator workstations.
2. Level two LAN shall connect programmable application controllers to other programmable application controllers, and to network controllers.
3. Level three LAN shall connect application-specific controllers to programmable application controllers and network controllers.

B. System architecture shall be modular and have inherent ability to expand to not less than two times system size indicated with no impact to performance indicated.

C. System architecture shall perform modifications without having to remove and replace existing network equipment.

D. Number of LANs and associated communication shall be transparent to operator. All I/O points residing on any LAN shall be capable of global sharing between all system LANs.

E. System design shall eliminate dependence on any single device for system alarm reporting and control execution. Each controller shall operate independently by performing its own control, alarm management and historical data collection.

2.6 DDC SYSTEM OPERATOR INTERFACES

A. Operator Means of System Access: Operator shall be able to access entire DDC system through any of multiple means, including, but not limited to, the following:

1. Desktop and portable operator workstation with hardwired connection through LAN port.
2. Portable operator terminal with hardwired connection through LAN port.
3. Portable operator workstation with wireless connection through LAN router.
4. PDA with wireless connection through LAN router.
5. Remote connection using outside of system personal computer or PDA through Web access.

B. Access to system, regardless of operator means used, shall be transparent to operator.

C. Desktop Workstations:

1. Connect to DDC system Level one LAN through a communications port directly on LAN or through a communications port on a DDC controller.
2. Able to communicate with any device located on any DDC system LAN.
3. Able to communicate remotely with any device connected to any DDC system LAN.
D.  Portable Workstations:
   1. Connect to DDC system Level one LAN through a communications port directly on LAN or through a communications port on a DDC controller.
   2. Able to communicate with any device located on any DDC system LAN.
   3. Connect to DDC system LAN through a communications port on an application-specific controller, or a room temperature sensor connected to an application-specific controller.
   4. Connect to system through a wireless router connected to Level one LAN.
   5. Portable workstation shall be able to communicate with any device connected to any system LAN regardless of point of physical connection to system.
   6. Monitor, program, schedule, adjust set points, and report capabilities of I/O connected anywhere in system.
   7. Have dynamic graphic displays that are identical to desktop workstations.

E. POT:
   1. Connect DDC controller through a communications port local to controller.
   2. Able to communicate with any DDC system controller that is directly connected or connected to DDC system.

F. Personal Digital Assistant:
   1. Connect to system through a wireless router connected to LAN.
   2. Able to communicate with any DDC controller connected to DDC system.

G. Critical Alarm Reporting:
   1. Operator-selected critical alarms shall be sent by DDC system to notify operator of critical alarms that require immediate attention.
   2. DDC system shall send alarm notification to multiple recipients that are assigned for each alarm.
   3. DDC system shall notify recipients by any or all means, including e-mail and text message.

H. Simultaneous Operator Use: Capable of accommodating up to 20 simultaneous operators that are accessing DDC system through any one of operator interfaces indicated.

2.7 NETWORK COMMUNICATION PROTOCOL

A. Network communication protocol(s) used throughout entire DDC system shall be open to public and available to other companies for use in making future modifications to DDC system.

B. ASHRAE 135 Protocol:
   1. ASHRAE 135 communication protocol shall be sole and native protocol used throughout entire DDC system.
   2. DDC system shall not require use of gateways except to integrate HVAC equipment and other building systems and equipment, not required to use ASHRAE 135 communication protocol.
   3. If used, gateways shall connect to DDC system using ASHRAE 135 communication protocol and Project object properties and read/write services indicated by interoperability schedule.
   4. Operator workstations, controllers and other network devices shall be tested and listed by BACnet Testing Laboratories.
2.8 SYSTEM SOFTWARE

A. System Software Minimum Requirements:

1. Real-time multitasking and multiuser 32 bit operating system that allows concurrent multiple operator workstations operating and concurrent execution of multiple real-time programs and custom program development.
2. Operating system shall be capable of operating DOS and Microsoft Windows applications.
3. Database management software shall manage all data on an integrated and non-redundant basis. Additions and deletions to database shall be without detriment to existing data. Include cross linkages so no data required by a program can be deleted by an operator until that data have been deleted from respective programs.
4. Network communications software shall manage and control multiple-network communications to provide exchange of global information and execution of global programs.
5. Operator interface software shall include day-to-day operator transaction processing, alarm and report handling, operator privilege level and data segregation control, custom programming, and online data modification capability.
6. Scheduling software shall schedule centrally based time and event, temporary, and exception day programs.

B. Operator Interface Software:

1. Minimize operator training through use of English language prorating and English language point identification.
2. Minimize use of a typewriter-style keyboard through use of a pointing device similar to a mouse.
3. Operator sign-off shall be a manual operation or, if no keyboard or mouse activity takes place, an automatic sign-off.
4. Automatic sign-off period shall be programmable from one to 60 minutes in one-minute increments on a per operator basis.
5. Operator sign-on and sign-off activity shall be recorded and sent to printer.
6. Security Access:
   a. Operator access to DDC system shall be under password control.
   b. An alphanumeric password shall be field assignable to each operator.
   c. Operators shall be able to access DDC system by entry of proper password.
   d. Operator password shall be same regardless of which computer or other interface means is used.
   e. Additions or changes made to passwords shall be updated automatically.
   f. Each operator shall be assigned an access level to restrict access to data and functions the operator is capable of performing.
   g. Software shall have at least five access levels.
   h. Each menu item shall be assigned an access level so that a one-for-one correspondence between operator assigned access level(s) and menu item access level(s) is required to gain access to menu item.
   i. Display menu items to operator with those capable of access highlighted. Menu and operator access level assignments shall be online programmable and under password control.

7. Data Segregation:

   a. Include data segregation for control of specific data routed to a workstation, to an operator or to a specific output device, such as a printer.
   b. Include at least 32 segregation groups.
   c. Segregation groups shall be selectable such as "fire points," "fire points on second floor," "space temperature points," "HVAC points," and so on.
Points shall be assignable to multiple segregation groups. Display and output of data to printer or monitor shall occur where there is a match of operator or peripheral segregation group assignment and point segregations.

Alarms shall be displayed and printed at each peripheral to which segregation allows, but only those operators assigned to peripheral and having proper authorization level will be allowed to acknowledge alarms.

Operators and peripherals shall be assignable to multiple segregation groups and all assignments are to be online programmable and under password control.

Operators shall be able to perform commands including, but not limited to, the following:

- Start or stop selected equipment.
- Adjust set points.
- Add, modify, and delete time programming.
- Enable and disable process execution.
- Lock and unlock alarm reporting for each point.
- Enable and disable totalization for each point.
- Enable and disable trending for each point.
- Override control loop set points.
- Enter temporary override schedules.
- Define holiday schedules.
- Change time and date.
- Enter and modify analog alarm limits.
- Enter and modify analog warning limits.
- View limits.
- Enable and disable demand limiting.
- Enable and disable duty cycle.
- Display logic programming for each control sequence.

Reporting:

- Generated automatically and manually.
- Sent to displays, printers and disk files.
- Types of Reporting:
  1) General listing of points.
  2) List points currently in alarm.
  3) List of off-line points.
  4) List points currently in override status.
  5) List of disabled points.
  6) List points currently locked out.
  7) List of items defined in a "Follow-Up" file.
  8) List weekly schedules.
  9) List holiday programming.
  10) List of limits and deadbands.

Summaries: For specific points, for a logical point group, for an operator selected group(s), or for entire system without restriction due to hardware configuration.

Graphic Interface Software:

Include a full interactive graphical selection means of accessing and displaying system data to operator. Include at least five levels with the penetration path operator assignable (for example, site, building, floor, air-handling unit, and supply temperature loop). Native language descriptors assigned to menu items are to be operator defined and modifiable under password control.
2. Include a hierarchical-linked dynamic graphic operator interface for accessing and displaying system data and commanding and modifying equipment operation. Interface shall use a pointing device with pull-down or penetrating menus, color and animation to facilitate operator understanding of system.

3. Include at least 10 levels of graphic penetration with the hierarchy operator assignable.

4. Descriptors for graphics, points, alarms and such shall be modified through operator's workstation under password control.

5. Graphic displays shall be online user definable and modifiable using the hardware and software provided.

6. Data to be displayed within a graphic shall be assignable regardless of physical hardware address, communication or point type.

7. Graphics are to be online programmable and under password control.

8. Points may be assignable to multiple graphics where necessary to facilitate operator understanding of system operation.

9. Graphics shall also contain software points.

10. Penetration within a graphic hierarchy shall display each graphic name as graphics are selected to facilitate operator understanding.

11. Back-trace feature shall permit operator to move upward in the hierarchy using a pointing device. Back trace shall show all previous penetration levels. Include operator with option of showing each graphic full screen size with back trace as horizontal header or by showing a "stack" of graphics, each with a back trace.

12. Display operator accessed data on the monitor.

13. Operator shall select further penetration using pointing device to click on a site, building, floor, area, equipment, and so on. Defined and linked graphic below that selection shall then be displayed.

14. Include operator with means to directly access graphics without going through penetration path.

15. Dynamic data shall be assignable to graphics.

16. Display points (physical and software) with dynamic data provided by DDC system with appropriate text descriptors, status or value, and engineering unit.

17. Use color, rotation, or other highly visible means, to denote status and alarm states. Color shall be variable for each class of points, as chosen by operator.

18. Points shall be dynamic with operator adjustable update rates on a per point basis from one second to over a minute.

19. For operators with appropriate privilege, points shall be commanded directly from display using pointing device.

a. For an analog command point such as set point, current conditions and limits shall be displayed and operator can position new set point using pointing device.

b. For a digital command point such as valve position, valve shall show its current state such as open or closed and operator could select alternative position using pointing device.

c. Keyboard equivalent shall be available for those operators with that preference.

20. Operator shall be able to split or resize viewing screen into quadrants to show one graphic on one quadrant of screen and other graphics or spreadsheet, bar chart, word processing, curve plot and other information on other quadrants on screen. This feature shall allow real-time monitoring of one part of system while displaying other parts of system or data to better facilitate overall system operation.

21. Help Features:

a. On-line context-sensitive help utility to facilitate operator training and understanding.

b. Bridge to further explanation of selected keywords. Document shall contain text and graphics to clarify system operation.
1) If help feature does not have ability to bridge on keywords for more information, a complete set of user manuals shall be provided in an indexed word-processing program, which shall run concurrently with operating system software.

c. Available for Every Menu Item:
   1) Index items for each system menu item.

22. Graphic generation software shall allow operator to add, modify, or delete system graphic displays.
   
   a. Include libraries of symbols depicting HVAC symbols such as fans, coils, filters, dampers, valves pumps, and electrical symbols similar to those indicated.
   
   b. Graphic development package shall use a pointing device in conjunction with a drawing program to allow operator to perform the following:
      
      1) Define background screens.
      2) Define connecting lines and curves.
      3) Locate, orient and size descriptive text.
      4) Define and display colors for all elements.
      5) Establish correlation between symbols or text and associated system points or other displays.

D. Project-Specific Graphics: Graphics documentation including, but not limited to, the following:

1. Site plan showing each building, and additional site elements, which are being controlled or monitored by DDC system.

2. Plan for each building floor, including interstitial floors, and each roof level of each building, showing the following:
   
   a. Room layouts with room identification and name.
   b. Locations and identification of all monitored and controlled HVAC equipment and other equipment being monitored and controlled by DDC system.
   c. Location and identification of each hardware point being controlled or monitored by DDC system.

3. Control schematic for each of following, including a graphic system schematic representation with point identification, set point and dynamic value indication.
   
   a. Energy-recovery systems.
   b. Fuel system.
   c. Heating hot-water system.
   d. Air-handling systems.
   e. Fan.
   f. Pump.
   g. Terminal unit.
   h. Other applicable equipment controlled by DDC system.

4. Graphic display for each piece of equipment connected to DDC system through a data communications link. Include dynamic indication of all points associated with equipment.

5. DDC system network riser diagram that shows schematic layout for entire system including all networks and all controllers, gateways, operator workstations, and other network devices.

E. Customizing Software:
1. Software to modify and tailor DDC system to specific and unique requirements of equipment installed, to programs implemented and to staffing and operational practices planned.

2. Online modification of DDC system configuration, program parameters, and database using menu selection and keyboard entry of data into preformatted display templates.

3. As a minimum, include the following modification capability:
   a. Operator assignment shall include designation of operator passwords, access levels, point segregation and auto sign-off.
   b. Peripheral assignment capability shall include assignment of segregation groups and operators to consoles and printers, designation of backup workstations and printers, designation of workstation header points and enabling and disabling of print-out of operator changes.
   c. System configuration and diagnostic capability shall include communications and peripheral port assignments, DDC controller assignments to network, DDC controller enable and disable, assignment of command trace to points and application programs and initiation of diagnostics.
   d. System text addition and change capability shall include English or native language descriptors for points, segregation groups and access levels and action messages for alarms, run time and trouble condition.
   e. Time and schedule change capability shall include time and date set, time and occupancy schedules, exception and holiday schedules and daylight savings time schedules.
   f. Point related change capability shall include the following:
      1) System and point enable and disable.
      2) Run-time enable and disable.
      3) Assignment of points to segregation groups, calibration tables, lockout, and run time and to a fixed I/O value.
      4) Assignment of alarm and warning limits.
   g. Application program change capability shall include the following:
      1) Enable and disable of software programs.
      2) Programming changes.
      3) Assignment of comfort limits, global points, time and event initiators, time and event schedules and enable and disable time and event programs.

4. Software shall allow operator to add points, or groups of points, to DDC system and to link them to energy optimization and management programs. Additions and modifications shall be online programmable using operator workstation, downloaded to other network devices and entered into their databases. After verification of point additions and associated program operation, database shall be uploaded and recorded on hard drive and disk for archived record.

5. Include high-level language programming software capability for implementation of custom DDC programs. Software shall include a compiler, linker, and up- and down-load capability.

6. Include a library of DDC algorithms, intrinsic control operators, arithmetic, logic and relational operators for implementation of control sequences. Also include, as a minimum, the following:
   a. Proportional control (P).
   b. Proportional plus integral (PI).
   c. Proportional plus integral plus derivative (PID).
   d. Adaptive and intelligent self-learning control.
      1) Algorithm shall monitor loop response to output corrections and adjust loop response characteristics according to time constant changes imposed.
Algorithm shall operate in a continuous self-learning manner and shall retain in memory a stored record of system dynamics so that on system shut down and restart, learning process starts from where it left off.

7. Fully implemented intrinsic control operators including sequence, reversing, ratio, time delay, time of day, highest select AO, lowest select AO, analog controlled digital output, analog control AO, and digitally controlled AO.

8. Logic operators such as "And," "Or," "Not," and others that are part of a standard set available with a high-level language.

9. Arithmetic operators such as "Add," "Subtract," "Multiply," "Divide," and others that are part of a standard set available with a high-level language.

10. Relational operators such as "Equal To," "Not Equal To," "Less Than," "Greater Than," and others that are part of a standard set available with a high-level language.

F. Alarm Handling Software:

1. Include alarm handling software to report all alarm conditions monitored and transmitted through DDC controllers, gateways, and other network devices.

2. Include first in, first out handling of alarms according to alarm priority ranking, with most critical alarms first, and with buffer storage in case of simultaneous and multiple alarms.

3. Alarm handling shall be active at all times to ensure that alarms are processed even if an operator is not currently signed on to DDC system.

4. Alarms display shall include the following:
   a. Indication of alarm condition such as "Abnormal Off," "Hi Alarm," and "Low Alarm."
   b. "Analog Value" or "Status" group and point identification with native language point descriptor such as "Space Temperature, Building 110, 2nd Floor, Room 212."
   c. Discrete per point alarm action message, such as "Call Maintenance Dept. Ext-5561."
   d. Include extended message capability to allow assignment and printing of extended action messages. Capability shall be operator programmable and assignable on a per point basis.

5. Alarms shall be directed to appropriate operator workstations, printers, and individual operators by privilege level and segregation assignments.

6. Send e-mail alarm messages to designated operators.

7. Send e-mail, page, text and voice messages to designated operators for critical alarms.

8. Alarms shall be categorized and processed by class.

   a. Class 1:
      1) Associated with fire, security and other extremely critical equipment monitoring functions; have alarm, trouble, return to normal, and acknowledge conditions printed and displayed.
      2) Unacknowledged alarms to be placed in unacknowledged alarm buffer.
      3) All conditions shall cause an audible sound and shall require individual acknowledgment to silence audible sound.

   b. Class 2:
      1) Critical, but not life-safety related, and processed same as Class 1 alarms, except do not require individual acknowledgment.
      2) Acknowledgement may be through a multiple alarm acknowledgment.

   c. Class 3:
1) General alarms; printed, displayed and placed in unacknowledged alarm buffer queues.
2) Each new alarm received shall cause an audible sound. Audible sound shall be silenced by "acknowledging" alarm or by pressing a "silence" key.
3) Acknowledgement of queued alarms shall be either on an individual basis or through a multiple alarm acknowledgement.
4) Alarms returning to normal condition shall be printed and not cause an audible sound or require acknowledgment.

d. Class 4:
1) Routine maintenance or other types of warning alarms.
2) Alarms to be printed only, with no display, no audible sound and no acknowledgment required.

9. Include an unacknowledged alarm indicator on display to alert operator that there are unacknowledged alarms in system. Operator shall be able to acknowledge alarms on an individual basis or through a multiple alarm acknowledge key, depending on alarm class.

10. To ensure that no alarm records are lost, it shall be possible to assign a backup printer to accept alarms in case of failure of primary printer.

G. Reports and Logs:
1. Include reporting software package that allows operator to select, modify, or create reports using DDC system I/O point data available.
2. Each report shall be definable as to data content, format, interval and date.
3. Report data shall be sampled and stored on DDC controller, within storage limits of DDC controller, and then uploaded to archive on server for historical reporting.
4. Operator shall be able to obtain real-time logs of all I/O points by type or status, such as alarm, point lockout, or normal.
5. Reports and logs shall be stored on server hard drives in a format that is readily accessible by other standard software applications, including spreadsheets and word processing.
6. Reports and logs shall be readily printed and set to be printed either on operator command or at a specific time each day.

H. Standard Reports: Standard DDC system reports shall be provided and operator shall be able to customize reports later.
1. All I/O: With current status and values.
2. Alarm: All current alarms, except those in alarm lockout.
3. Disabled I/O: All I/O points that are disabled.
4. Alarm Lockout I/O: All I/O points in alarm lockout, whether manual or automatic.
5. Alarm Lockout I/O in Alarm: All I/O in alarm lockout that are currently in alarm.
6. Logs:
   a. Alarm history.
   b. System messages.
   c. System events.
   d. Trends.

I. Custom Reports: Operator shall be able to easily define any system data into a daily, weekly, monthly, or annual report. Reports shall be time and date stamped and shall contain a report title.

J. Standard Trends:
1. Trend all I/O point present values, set points, and other parameters indicated for trending.
2. Trends shall be associated into groups, and a trend report shall be set up for each group.
3. Trends shall be stored within DDC controller and uploaded to hard drives automatically on reaching 75 of DDC controller buffer limit, or by operator request, or by archiving time schedule.
4. Preset trend intervals for each I/O point after review with Owner.
5. Trend intervals shall be operator selectable from 10 seconds up to 60 minutes. Minimum number of consecutive trend values stored at one time shall be 100 per variable.
6. When drive storage memory is full, most recent data shall overwrite oldest data.
7. Archived and real-time trend data shall be available for viewing numerically and graphically by operators.
8. Trend data for trended points shall be accessible by left or right clicking on a point from the associated graphic.

K. Custom Trends: Operator shall be able to define a custom trend log for any I/O point in DDC system.
1. Each trend shall include interval, start time, and stop time.
2. Data shall be sampled and stored on DDC controller, within storage limits of DDC controller, and then uploaded to archive on server hard drives.
3. Data shall be retrievable for use in spreadsheets and standard database programs.

L. Programming Software:
1. Include programming software to execute sequences of operation indicated.
2. Include programming routines in simple and easy to follow logic with detailed text comments describing what the logic does and how it corresponds to sequence of operation.
3. Programming software shall be as follows:
   a. Graphic Based: Programming shall use a library of function blocks made from preprogrammed code designed for DDC control systems.
      1) Function blocks shall be assembled with interconnection lines that represent to control sequence in a flowchart.
      2) Programming tools shall be viewable in real time to show present values and logical results of each function block.
   b. Menu Based: Programming shall be done by entering parameters, definitions, conditions, requirements and constraints.
   c. Line by Line and Text Based: Programming shall declare variable types such as local, global, real, integer, and so on, at the beginning of the program. Use descriptive comments frequently to describe programming code.
4. Include means for detecting programming errors and testing software control strategies with a simulation tool before implementing in actual control. Simulation tool may be inherent with programming software or as a separate product.

M. Database Management Software:
1. Where a separate SQL database is used for information storage, DDC system shall include database management software that separates database monitoring and managing functions by supporting multiple separate windows.
2. Database secure access shall be accomplished using standard SQL authentication including ability to access data for use outside of DDC system applications.
3. Database management function shall include summarized information on trend, alarm, event, and audit for the following database management actions:
a. Backup.
b. Purge.
c. Restore.

4. Database management software shall support the following:
   a. Statistics: Display database server information and trend, alarm, event, and audit information on database.
   b. Maintenance: Include method of purging records from trend, alarm, event and audit databases by supporting separate screens for creating a backup before purging, selecting database, and allowing for retention of a selected number of day's data.
   c. Backup: Include means to create a database backup file and select a storage location.
   d. Restore: Include a restricted means of restoring a database by requiring operator to have proper security level.

5. Database management software shall include information of current database activity, including the following:
   a. Ready.
   b. Purging record from a database.
   c. Action failed.
   d. Refreshing statistics.
   e. Restoring database.
   f. Shrinking a database.
   g. Backing up a database.
   h. Resetting Internet information services.
   i. Starting network device manager.
   j. Shutting down the network device manager.
   k. Action successful.

6. Database management software monitoring functions shall continuously read database information once operator has logged on.

7. Include operator notification through on-screen pop-up display and e-mail message when database value has exceeded a warning or alarm limit.

8. Monitoring settings window shall have the following sections:
   a. Allow operator to set and review scan intervals and start times.
   b. E-mail: Allow operator to create and review e-mail and phone text messages to be delivered when a warning or an alarm is generated.
   c. Warning: Allow operator to define warning limit parameters, set reminder frequency and link e-mail message.
   d. Alarm: Allow operator to define alarm limit parameters, set reminder frequency and link e-mail message.
   e. Database Login: Protect system from unauthorized database manipulation by creating a read access and a write access for each of trend, alarm, event and audit databases as well as operator proper security access to restore a database.

9. Monitoring settings taskbar shall include the following informational icons:
   a. Normal: Indicates by color and size, or other easily identifiable means that all databases are within their limits.
   b. Warning: Indicates by color and size, or other easily identifiable means that one or more databases have exceeded their warning limit.
   c. Alarm: Indicates by color and size, or other easily identifiable means that one or more databases have exceeded their alarm limit.
2.9 ASHRAE 135 GATEWAYS

A. Include BACnet communication ports, whenever available as an equipment OEM standard option, for integration via a single communication cable. BACnet-controlled plant equipment includes, but is not limited to, boilers, and variable-speed drives.

B. Include gateways to connect BACnet to legacy systems, existing non-BACnet devices, and existing non-BACnet DDC-controlled equipment, only when specifically requested and approved by Owner.

C. Include with each gateway an interoperability schedule showing each point or event on legacy side that BACnet “client” will read, and each parameter that BACnet network will write to. Describe this interoperability of BACnet services, or BIBBs, defined in ASHRAE 135, Annex K.

D. Gateway Minimum Requirements:
   1. Read and view all readable object properties on non-BACnet network to BACnet network and vice versa where applicable.
   2. Write to all writeable object properties on non-BACnet network from BACnet network and vice versa where applicable.
   3. Include single-pass (only one protocol to BACnet without intermediary protocols) translation from non-BACnet protocol to BACnet and vice versa.
   4. Comply with requirements of Data Sharing Read Property, Data Sharing Write Property, Device Management Dynamic Device Binding-B, and Device Management Communication Control BIBBs according to ASHRAE 135.
   5. Hardware, software, software licenses, and configuration tools for operator-to-gateway communications.
   6. Backup programming and parameters on CD media and the ability to modify, download, backup, and restore gateway configuration.

2.10 DDC CONTROLLERS

A. DDC system shall consist of a combination of network controllers, programmable application controllers and application-specific controllers to satisfy performance requirements indicated.

B. DDC controllers shall perform monitoring, control, energy optimization and other requirements indicated.

C. DDC controllers shall use a multitasking, multiuser, real-time digital control microprocessor with a distributed network database and intelligence.

D. Each DDC controller shall be capable of full and complete operation as a completely independent unit and as a part of a DDC system wide distributed network.

E. Environment Requirements:
   1. Controller hardware shall be suitable for the anticipated ambient conditions.
   2. Controllers located in conditioned space shall be rated for operation at the applicable temperature range.
   3. Controllers located outdoors shall be rated for operation at the applicable temperature range.

F. Power and Noise Immunity:
   1. Controller shall operate at 90 to 110 percent of nominal voltage rating and shall perform an orderly shutdown below 80 percent of nominal voltage.
2. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios with up to 5 W of power located within 36 inches of enclosure.

G. DDC Controller Spare Processing Capacity:

1. Include spare processing memory for each controller. RAM, PROM, or EEPROM will implement requirements indicated with the following spare memory:
   b. Programmable Application Controllers: Not less than 25 percent.
   c. Application-Specific Controllers: Not less than 25 percent.

2. Memory shall support DDC controller's operating system and database and shall include the following:
   a. Monitoring and control.
   b. Energy management, operation and optimization applications.
   c. Alarm management.
   d. Historical trend data of all connected I/O points.
   e. Maintenance applications.
   f. Operator interfaces.
   g. Monitoring of manual overrides.

H. DDC Controller Spare I/O Point Capacity: Include spare I/O point capacity for each controller as follows:

1. Network Controllers:
   a. 10 percent of each AI, AO, BI, and BO point connected to controller.
   b. Minimum Spare I/O Points per Controller:
      1) AIs: Two.
      2) AOs: Two.
      3) BIs: Two.
      4) BOs: Two.

2. Programmable Application Controllers:
   a. 10 percent of each AI, AO, BI, and BO point connected to controller.
   b. Minimum Spare I/O Points per Controller:
      1) AIs: Two.
      2) AOs: One.
      3) BIs: One.
      4) BOs: Two.

3. Application-Specific Controllers:
   a. 10 percent of each AI, AO, BI, and BO point connected to controller.
   b. Minimum Spare I/O Points per Controller:
      1) AIs: One.
      2) AOs: One.
      3) BIs: One.
      4) BOs: One.
I. Maintenance and Support: Include the following features to facilitate maintenance and support:

1. Mount microprocessor components on circuit cards for ease of removal and replacement.
2. Means to quickly and easily disconnect controller from network.
3. Means to quickly and easily access connect to field test equipment.
4. Visual indication that controller electric power is on, of communication fault or trouble, and that controller is receiving and sending signals to network.

J. Input and Output Point Interface:

1. Hardwired input and output points shall connect to network, programmable application and application-specific controllers.
2. Input and output points shall be protected so shorting of point to itself, to another point, or to ground will not damage controller.
3. Input and output points shall be protected from voltage up to 24 V of any duration so that contact will not damage controller.
4. AIs:
   a. AIs shall include monitoring of low-voltage (zero- to 10-V dc), current (4 to 20 mA) and resistance signals from thermistor and RTD sensors.
   b. AIs shall be compatible with, and field configurable to, sensor and transmitters installed.
   c. Controller AIs shall perform analog-to-digital (A-to-D) conversion with a minimum resolution of 8 bits or better to comply with accuracy requirements indicated.
   d. Signal conditioning including transient rejection shall be provided for each AI.
   e. Capable of being individually calibrated for zero and span.
   f. Incorporate common-mode noise rejection of at least 50 dB from zero to 100 Hz for differential inputs, and normal-mode noise rejection of at least 20 dB at 60 Hz from a source impedance of 10000 ohms.

5. AOs:
   a. Controller AOs shall perform analog-to-digital (A-to-D) conversion with a minimum resolution of 8 bits or better to comply with accuracy requirements indicated.
   b. Output signals shall have a range of 4 to 20 mA dc or zero- to 10-V dc as required to include proper control of output device.
   c. Capable of being individually calibrated for zero and span.
   d. AOs shall not exhibit a drift of greater than 0.4 percent of range per year.

6. BIs:
   a. Controller BIs shall accept contact closures and shall ignore transients of less than 5-ms duration.
   b. Isolation and protection against an applied steady-state voltage of up to 180-V ac peak.
   c. BIs shall include a wetting current of at least 12 mA to be compatible with commonly available control devices and shall be protected against effects of contact bounce and noise.
   d. BIs shall sense "dry contact" closure without external power (other than that provided by the controller) being applied.
   e. Pulse accumulation input points shall comply with all requirements of BIs and accept up to 10 pulses per second for pulse accumulation. Buffer shall be provided to totalize pulses. Pulse accumulator shall accept rates of at least 20 pulses per second. The totalized value shall be reset to zero on operator's command.
a. Controller BOs shall include relay contact closures or triac outputs for momentary and maintained operation of output devices.

1) Relay contact closures shall have a minimum duration of 0.1 second. Relays shall include at least 180 V of isolation. Electromagnetic interference suppression shall be provided on all output lines to limit transients to non-damaging levels. Minimum contact rating shall be 1 A at 24-V ac.
2) Triac outputs shall include at least 180 V of isolation. Minimum contact rating shall be 1 A at 24-V ac.

b. BOs shall include for two-state operation or a pulsed low-voltage signal for pulse-width modulation control.

c. BOs shall be selectable for either normally open or normally closed operation.

d. Include tristate outputs (two coordinated BOs) for control of three-point floating-type electronic actuators without feedback.

e. Limit use of three-point floating devices to VAV terminal unit control applications, and other applications indicated on Drawings. Control algorithms shall operate actuator to one end of its stroke once every 24 hours for verification of operator tracking.

2.11 NETWORK CONTROLLERS

A. General Network Controller Requirements:

1. Include adequate number of controllers to achieve performance indicated.
2. System shall consist of one or more independent, standalone, microprocessor-based network controllers to manage global strategies indicated.
3. Controller shall have enough memory to support its operating system, database, and programming requirements.
4. Data shall be shared between networked controllers and other network devices.
5. Operating system of controller shall manage input and output communication signals to allow distributed controllers to share real and virtual object information and allow for central monitoring and alarms.
6. Controllers that perform scheduling shall have a real-time clock.
7. Controller shall continually check status of its processor and memory circuits. If an abnormal operation is detected, controller shall assume a predetermined failure mode and generate an alarm notification.
8. Controllers shall be fully programmable.

B. Communication:

1. Network controllers shall communicate with other devices on DDC system Level one network.
2. Network controller also shall perform routing if connected to a network of programmable application and application-specific controllers.

C. Operator Interface:

1. Controller shall be equipped with a service communications port for connection to a portable operator's workstation.

D. Serviceability:

1. Controller shall be equipped with diagnostic LEDs or other form of local visual indication of power, communication, and processor.
2. Wiring and cable connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
3. Controller shall maintain BIOS and programming information in event of a power loss.

2.12 PROGRAMMABLE APPLICATION CONTROLLERS

A. General Programmable Application Controller Requirements:

1. Include adequate number of controllers to achieve performance indicated.
2. Controller shall have enough memory to support its operating system, database, and programming requirements.
3. Data shall be shared between networked controllers and other network devices.
4. Operating system of controller shall manage input and output communication signals to allow distributed controllers to share real and virtual object information and allow for central monitoring and alarms.
5. Controllers shall have a real-time clock.
6. Controller shall continually check status of its processor and memory circuits. If an abnormal operation is detected, controller shall assume a predetermined failure mode and generate an alarm notification.
7. Controllers shall be fully programmable.

B. Communication:

1. Programmable application controllers shall communicate with other devices on network.

C. Operator Interface:

1. Controller shall be equipped with a service communications port for connection to a portable operator's workstation.

D. Serviceability:

1. Controller shall be equipped with diagnostic LEDs or other form of local visual indication of power, communication, and processor.
2. Wiring and cable connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
3. Controller shall maintain BIOS and programming information in event of a power loss.

2.13 APPLICATION-SPECIFIC CONTROLLERS

A. Description: Microprocessor-based controllers, which through hardware or firmware design are dedicated to control a specific piece of equipment. Controllers are not fully user-programmable but are configurable and customizable for operation of equipment they are designed to control.

1. Capable of standalone operation and shall continue to include control functions without being connected to network.
2. Data shall be shared between networked controllers and other network devices.

B. Communication: Application-specific controllers shall communicate with other application-specific controller and devices on network, and to programmable application and network controllers.
C. Operator Interface: Controller shall be equipped with a service communications port for connection to a portable operator's workstation. Connection shall extend to port on space temperature sensor that is connected to controller.

D. Serviceability:

1. Controller shall be equipped with diagnostic LEDs or other form of local visual indication of power, communication, and processor.
2. Wiring and cable connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
3. Controller shall use nonvolatile memory and maintain all BIOS and programming information in event of power loss.

2.14 CONTROLLER SOFTWARE

A. General Controller Software Requirements:

1. Software applications shall reside and operate in controllers. Editing of applications shall occur at operator workstations.
2. I/O points shall be identified by up to 30 character point name and up to 16 character point descriptor. Same names shall be used at operator workstations.
3. Control functions shall be executed within controllers using DDC algorithms.
4. Controllers shall be configured to use stored default values to ensure fail-safe operation. Default values shall be used when there is a failure of a connected input instrument or loss of communication of a global point value.

B. Security:

1. Operator access shall be secured using individual security passwords and user names.
2. Passwords shall restrict operator to points, applications, and system functions as assigned by system manager.
3. Operator log-on and log-off attempts shall be recorded.
4. System shall protect itself from unauthorized use by automatically logging off after last keystroke. The delay time shall be operator-definable.

C. Scheduling: Include capability to schedule each point or group of points in system. Each schedule shall consist of the following:

1. Weekly Schedule:
   a. Include separate schedules for each day of week.
   b. Each schedule should include the capability for start, stop, optimal start, optimal stop, and night economizer.
   c. Each schedule may consist of up to 10 events.
   d. When a group of objects are scheduled together, include capability to adjust start and stop times for each member.

2. Exception Schedules:
   a. Include ability for operator to designate any day of the year as an exception schedule.
   b. Exception schedules may be defined up to a year in advance. Once an exception schedule is executed, it will be discarded and replaced by regular schedule for that day of week.
3. Holiday Schedules:
   a. Include capability for operator to define up to 99 special or holiday schedules.
   b. Schedules may be placed on scheduling calendar and will be repeated each year.
   c. Operator shall be able to define length of each holiday period.

D. System Coordination:
   1. Include standard application for proper coordination of equipment.
   2. Application shall include operator with a method of grouping together equipment based on function and location.
   3. Group may then be used for scheduling and other applications.

E. Binary Alarms:
   1. Each binary point shall be set to alarm based on operator-specified state.
   2. Include capability to automatically and manually disable alarming.

F. Analog Alarms:
   1. Each analog object shall have both high and low alarm limits.
   2. Alarming shall be able to be automatically and manually disabled.

G. Alarm Reporting:
   1. Operator shall be able to determine action to be taken in event of an alarm.
   2. Alarms shall be routed to appropriate operator workstations based on time and other conditions.
   3. Alarm shall be able to start programs, print, be logged in event log, generate custom messages, and display graphics.

H. Remote Communication:
   1. System shall have ability to dial out in the event of an alarm.

I. Electric Power Demand Limiting:
   1. Demand-limiting program shall monitor building or other operator-defined electric power consumption from signals connected to electric power meter or from a watt transducer or current transformer.
   2. Demand-limiting program shall predict probable power demand such that action can be taken to prevent exceeding demand limit. When demand prediction exceeds demand limit, action will be taken to reduce loads in a predetermined manner. When demand prediction indicates demand limit will not be exceeded, action will be taken to restore loads in a predetermined manner.
   3. Demand reduction shall be accomplished by the following means:
      a. Reset air-handling unit supply temperature set points.
      b. Reset space temperature set points.
      c. De-energize equipment based on priority.
   4. Demand-limiting parameters, frequency of calculations, time intervals, and other relevant variables shall be based on the means by which electric power service provider computes demand charges.
   5. Include demand-limiting prediction and control for any individual meter monitored by system or for total of any combination of meters.
6. Include means operator to make the following changes online:
   a. Addition and deletion of loads controlled.
   b. Changes in demand intervals.
   c. Changes in demand limit for meter(s).
   d. Maximum shutoff time for equipment.
   e. Minimum shutoff time for equipment.
   f. Select rotational or sequential shedding and restoring.
   g. Shed and restore priority.

7. Include the following information and reports, to be available on an hourly, daily, weekly, monthly and annual basis:
   a. Total electric consumption.
   b. Peak demand.
   c. Date and time of peak demand.
   d. Daily peak demand.

J. Maintenance Management: System shall monitor equipment status and generate maintenance messages based on operator-designated run-time, starts, and calendar date limits.

K. Sequencing: Include application software based on sequences of operation indicated to properly sequence chillers, boilers, and other applicable HVAC equipment.

L. Control Loops:
   1. Support any of the following control loops, as applicable to control required:
      a. Two-position (on/off, open/close, slow/fast) control.
      b. Proportional control.
      c. Proportional plus integral (PI) control.
      d. Proportional plus integral plus derivative (PID) control.
         1) Include PID algorithms with direct or reverse action and anti-windup.
         2) Algorithm shall calculate a time-varying analog value used to position an output or stage a series of outputs.
         3) Controlled variable, set point, and PID gains shall be operator-selectable.
      e. Adaptive (automatic tuning).

M. Staggered Start: Application shall prevent all controlled equipment from simultaneously restarting after a power outage. Order which equipment (or groups of equipment) is started, along with the time delay between starts, shall be operator-selectable.

N. Energy Calculations:
   1. Include software to allow instantaneous power or flow rates to be accumulated and converted to energy usage data.
   2. Include an algorithm that calculates a sliding-window average (rolling average). Algorithm shall be flexible to allow window intervals to be operator specified (such as 15, 30, or 60 minutes).
   3. Include an algorithm that calculates a fixed-window average. A digital input signal shall define start of window period (such as signal from utility meter) to synchronize fixed-window average with that used by utility.
O. Anti-Short Cycling:
   1. BO points shall be protected from short cycling.
   2. Feature shall allow minimum on-time and off-time to be selected.

P. On and Off Control with Differential:
   1. Include an algorithm that allows a BO to be cycled based on a controlled variable and set point.
   2. Algorithm shall be direct- or reverse-acting and incorporate an adjustable differential.

Q. Run-Time Totalization:
   1. Include software to totalize run-times for all BI and BO points.
   2. A high run-time alarm shall be assigned, if required, by operator.

2.15 ENCLOSURES

A. General Enclosure Requirements:
   1. House each controller and associated control accessories in an enclosure. Enclosure shall serve as central tie-in point for control devices such as switches, transmitters, transducers, power supplies and transformers.
   2. Include enclosure door with key locking mechanism. Key locks alike for all enclosures and include one pair of keys per enclosure.
   3. Equip doors of enclosures housing controllers and components with analog or digital displays with windows to allow visual observation of displays without opening enclosure door.
   4. Include wall-mounted enclosures with brackets suitable for mounting enclosures to wall or freestanding support stand as indicated.
   5. Supply each enclosure with a complete set of as-built schematics, tubing, and wiring diagrams and product literature located in a pocket on inside of door.

B. Internal Arrangement:
   1. Internal layout of enclosure shall group and protect pneumatic, electric, and electronic components associated with a controller, but not an integral part of controller.
   2. Arrange layout to group similar products together.
   3. Include a barrier between line-voltage and low-voltage electrical and electronic products.
   4. Factory or shop install products, tubing, cabling and wiring complying with requirements and standards indicated.
   5. Terminate field cable and wire using heavy-duty terminal blocks.
   6. Include spare terminals, equal to not less than 10 percent of used terminals.
   7. Include spade lugs for stranded cable and wire.
   8. Install a maximum of two wires on each side of a terminal.
   9. Include enclosure field power supply with a toggle-type switch located at entrance inside enclosure to disconnect power.
   10. Include enclosure with a line-voltage nominal 20-A GFCI duplex receptacle for service and testing tools. Wire receptacle on hot side of enclosure disconnect switch and include with a 5-A circuit breaker.
   11. Mount products within enclosure on removable internal panel(s).
   12. Include products mounted in enclosures with engraved, laminated phenolic nameplates (black letters on a white background). The nameplates shall have at least 1/4-inch-high lettering.
   13. Route tubing cable and wire located inside enclosure within a raceway with a continuous removable cover.
14. Label each end of cable, wire and tubing in enclosure following an approved identification system that extends from field I/O connection and all intermediate connections throughout length to controller connection.

15. Size enclosure internal panel to include at least 25 percent spare area on face of panel.

C. Environmental Requirements:

1. Evaluate temperature and humidity requirements of each product to be installed within each enclosure.

2. Calculate enclosure internal operating temperature considering heat dissipation of all products installed within enclosure and ambient effects (solar, conduction and wind) on enclosure.

3. Where required by application, include temperature-controlled electrical heat to maintain inside of enclosure above minimum operating temperature of product with most stringent requirement.

4. Where required by application, include temperature-controlled ventilation fans with filtered louver(s) to maintain inside of enclosure below maximum operating temperature of product with most stringent requirement.

D. Wall-Mounted, NEMA 250, Type 1:

1. Manufacturers: Subject to compliance with requirements, provide products from the following:
   a. Hoffman; a brand of Pentair Equipment Protection.

2. Enclosure shall be NRTL listed according to UL 50 or UL 50E.

3. Construct enclosure of steel, not less than:
   a. Enclosure size less than 24 in.: 0.053 in. thick.
   b. Enclosure size 24 in. and larger: 0.067 in. thick.

4. Finish enclosure inside and out with polyester powder coating that is electrostatically applied and then baked to bond to substrate.
   a. Exterior color shall be manufacturer's standard.
   b. Interior color shall be manufacturer's standard.

5. Hinged door full size of front face of enclosure and supported using:
   a. Enclosures sizes less than 36 in. tall: Multiple butt hinges.
   b. Enclosures sizes 36 in. tall and larger: Continuous piano hinges.

6. Removable internal panel with a white polyester powder coating that is electrostatically applied and then baked to bond to substrate.
   a. Size less than 24 in.: Solid or Perforated steel, 0.053 in. thick.
   b. Size 24 in. and larger: Solid steel, 0.093 in. thick.

7. Internal panel mounting hardware, grounding hardware and sealing washers.

8. Grounding stud on enclosure body.

9. Thermoplastic pocket on inside of door for record Drawings and Product Data.

E. Wall Mounted NEMA 250, Types 4 and 12:

1. Manufacturers: Subject to compliance with requirements, provide products from the following:
a. Hoffman; a brand of Pentair Equipment Protection.

2. Enclosure shall be NRTL listed according to UL 508A.
3. Seam and joints are continuously welded and ground smooth.
4. Where recessed enclosures are indicated, include enclosures with face flange for flush mounting.
5. Externally formed body flange around perimeter of enclosure face for continuous perimeter seamless gasket door seal.
6. Single-door enclosure sizes up to 60 inches tall by 36 inches wide.
7. Double-door enclosure sizes up to 36 inches tall by 60 inches wide.
8. Construct enclosure of steel, not less than the following:
   a. Size Less Than 24 Inches: 0.053 inch thick.
   b. Size 24 Inches and Larger: 0.067 inch thick.
9. Finish enclosure with polyester powder coating that is electrostatically applied and then baked to bond to substrate.
   a. Exterior color shall be manufacturer's standard.
   b. Interior color shall be manufacturer's standard.
10. Corner-formed door, full size of enclosure face, supported using multiple concealed hinges with easily removable hinge pins.
    a. Sizes through 24 Inches Tall: Two hinges.
    b. Sizes between 24 Inches through 48 Inches Tall: Three hinges.
    c. Sizes Larger 48 Inches Tall: Four hinges.
11. Double-door enclosures with overlapping door design to include unobstructed full-width access.
    a. Single-door enclosures 48 inches and taller, and all double-door enclosures, with three-point (top, middle and bottom) latch system.
12. Removable internal panel with a white polyester powder coating that is electrostatically applied and then baked to bond to substrate.
    a. Size Less Than 24 Inches: Solid or perforated steel, 0.053 inch thick.
    b. Size 24 Inches and Larger: Solid steel, 0.093 inch thick.
13. Internal panel mounting studs with hardware, grounding hardware, and sealing washers.
15. Thermoplastic pocket on inside of door for record Drawings and Product Data.

F. Accessories:
1. Electric Heater:
   a. Aluminum housing with brushed finish.
   b. Thermostatic control with adjustable set point from zero to 100 deg F.
   c. Capacity: 100, 200, 400, and 800 W as required by application.
   d. Fan draws cool air from bottom of enclosure and passes air across thermostat and heating elements before being released into enclosure cavity. Heated air is discharged through the top of heater.
2. Ventilation Fans, Filtered Intake and Exhaust Grilles:
a. Number and size of fans, filters and grilles as required by application.
b. Compact cooling fans engineered for 50,000 hours of continuous operation without lubrication or service.
c. Fans capable of being installed on any surface and in any position within enclosure for spot cooling or air circulation.
d. Thermostatic control with adjustable set point from 32 to 140 deg F.
e. Airflow Capacity at Zero Pressure:
   1) 4-Inch Fan: 100 cfm.
   2) 6-Inch Fan: 240 cfm.
   3) 10-Inch Fan: 560 cfm.
f. Maximum operating temperature of 158 deg F.
g. 4-inch fan thermally protected and provided with permanently lubricated ball-bearings.
h. 6- and 10-inch fans with ball-bearing construction and split capacitor motors thermally protected to avoid premature failure.
i. Dynamically balanced impellers molded from polycarbonate material.
j. Fan furnished with power cord and polarized plug for power connection.
k. Fan brackets, finger guards and mounting hardware provided with fans to complete installation.
l. Removable Intake and Exhaust Grilles: ABS plastic or stainless steel of size to match fan size and suitable for NEMA 250, Types 1 and 12 enclosures.
m. Filters for NEMA 250, Type 1 Enclosures: Washable foam or aluminum, of a size to match intake grille.
n. Filters for NEMA 250, Type 12 Enclosures: Disposable, of a size to match intake grille.

3. Framed Fixed Window Kit for NEMA 250, Types 4, 4X, and 12 Enclosures:
   a. 0.25-inch-thick, scratch-resistant acrylic or polycarbonate window mounted in a metal frame matching adjacent door material.
   b. Enclosure types, except NEMA 250 Type 1, shall have a continuous gasket material around perimeter of window and frame to provide watertight seal.
   c. Window kit shall be factory or shop installed before shipment to Project.

4. Frameless Fixed Window Kit for NEMA 250, Type 1 Enclosures:
   a. 0.125-inch-thick, polycarbonate window mounted in enclosure door material.
   b. Window attached to door with screw fasteners and continuous strip of high-strength double-sided tape around window perimeter.
   c. Window kit shall be factory or shop installed before shipment to Project.

5. Frame Fixed or Hinged Window Kit for NEMA 250, Types 1 and 12 Enclosures:
   a. 0.25-inch-thick, scratch-resistant acrylic or polycarbonate window mounted in a metal frame matching adjacent door material.
   b. Enclosure types, except NEMA 250 Type 1, shall have a continuous gasket material around perimeter of window and frame to provide watertight seal.
   c. Window kit shall be factory or shop installed before shipment to Project.

2.16 RELAYS

A. General-Purpose Relays:

1. Manufacturers: Subject to compliance with requirements, provide products from the following:
   a. Functional Devices

2. Relays shall be heavy duty and rated for at least 10 A at 250-V ac and 60 Hz.
3. Relays shall be either double pole double throw (DPDT) or three-pole double throw, depending on the control application.
4. Use a plug-in-style relay with an eight-pin octal plug for DPDT relays and an 11-pin octal plug for three-pole double-throw relays.
5. Construct the contacts of either silver cadmium oxide or gold.
6. Enclose the relay in a clear transparent polycarbonate dust-tight cover.
7. Relays shall have LED indication and a manual reset and push-to-test button.
8. Performance:
   a. Mechanical Life: At least 10 million cycles.
   b. Electrical Life: At least 100,000 cycles at rated load.
   c. Pickup Time: 15 ms or less.
   d. Dropout Time: 10 ms or less.
   e. Pull-in Voltage: 85 percent of rated voltage.
   f. Dropout Voltage: 50 percent of nominal rated voltage.
   g. Power Consumption: 2 VA.
   h. Ambient Operating Temperatures: Minus 40 to 115 deg F.
9. Equip relays with coil transient suppression to limit transients to non-damaging levels.
10. Plug each relay into an industry-standard, 35-mm DIN rail socket. Plug all relays located in control panels into sockets that are mounted on a DIN rail.
11. Relay socket shall have screw terminals. Mold into the socket the coincident screw terminal numbers and associated octal pin numbers.

B. Multifunction Time-Delay Relays:

1. Manufacturers: Subject to compliance with requirements, provide products from the following:
   a. Functional Devices

2. Relays shall be continuous duty and rated for at least 10 A at 240-V ac and 60 Hz.
3. Relays shall be DPDT relay with up to eight programmable functions to provide on/off delay, interval and recycle timing functions.
4. Use a plug-in-style relay with either an 8- or 11-pin octal plug.
5. Construct the contacts of either silver cadmium oxide or gold.
6. Enclose the relay in a dust-tight cover.
7. Include knob and dial scale for setting delay time.
8. Performance:
   a. Mechanical Life: At least 10 million cycles.
   b. Electrical Life: At least 100,000 cycles at rated load.
   c. Timing Ranges: Multiple ranges from 0.1 seconds to 100 minutes.
   d. Repeatability: Within 2 percent.
   e. Recycle Time: 45 ms.
   f. Minimum Pulse Width Control: 50 ms.
   g. Power Consumption: 5 VA or less at 120-V ac.
h. Ambient Operating Temperatures: Minus 40 to 115 deg F.

9. Equip relays with coil transient suppression to limit transients to non-damaging levels.
10. Plug each relay into an industry-standard, 35-mm DIN rail socket. Plug all relays located in control panels into sockets that are mounted on a DIN rail.
11. Relay socket shall have screw terminals. Mold into the socket the coincident screw terminal numbers and associated octal pin numbers.

C. Latching Relays:

1. Manufacturers: Subject to compliance with requirements, provide products from the following:
   a. Functional Devices

2. Relays shall be continuous duty and rated for at least 10 A at 250-V ac and 60 Hz.
3. Relays shall be either DPDT or three-pole double throw, depending on the control application.
4. Use a plug-in-style relay with a multibladed plug.
5. Construct the contacts of either silver cadmium oxide or gold.
6. Enclose the relay in a clear transparent polycarbonate dust-tight cover.
7. Performance:
   a. Mechanical Life: At least 10 million cycles.
   b. Electrical Life: At least 100,000 cycles at rated load.
   c. Pickup Time: 15 ms or less.
   d. Dropout Time: 10 ms or less.
   e. Pull-in Voltage: 85 percent of rated voltage.
   f. Dropout Voltage: 50 percent of nominal rated voltage.
   g. Power Consumption: 2 VA.
   h. Ambient Operating Temperatures: Minus 40 to 115 deg F.

8. Equip relays with coil transient suppression to limit transients to non-damaging levels.
9. Plug each relay into an industry-standard, 35-mm DIN rail socket. Plug all relays located in control panels into sockets that are mounted on a DIN rail.
10. Relay socket shall have screw terminals. Mold into the socket the coincident screw terminal numbers and associated octal pin numbers.

D. Current Sensing Relay:

1. Manufacturers: Subject to compliance with requirements, provide products from the following:
   a. Functional Devices
   b. Hawkeye

2. Monitors ac current.
3. Independent adjustable controls for pickup and dropout current.
4. Energized when supply voltage is present and current is above pickup setting.
5. De-energizes when monitored current is below dropout current.
6. Dropout current is adjustable from 50 to 95 percent of pickup current.
7. Include a current transformer, if required for application.
8. House current sensing relay and current transformer in its own enclosure. Use NEMA 250, Type 12 enclosure for indoors and NEMA 250, Type 4 for outdoors.

E. Combination On-Off Status Sensor and On-Off Relay:
1. Manufacturers: Subject to compliance with requirements, provide products from the following:
   a. Functional Devices

2. Description:
   a. On-off control and status indication in a single device.
   b. LED status indication of activated relay and current trigger.
   c. Closed-Open-Auto override switch located on the load side of the relay.

3. Performance:
   a. Ambient Temperature: Minus 30 to 140 deg F.

4. Status Indication:
   a. Current Sensor: Integral sensing for single-phase loads up to 20 A and external solid or split sensing ring for three-phase loads up to 150 A.
   b. Current Sensor Range: As required by application.
   c. Current Set Point: Fixed or adjustable as required by application.
   d. Current Sensor Output:
      1) Solid-state, single-pole double-throw contact rated for 30-V ac and dc and for 0.4 A.
      2) Solid-state, single-pole double-throw contact rated for 120-V ac and 1.0 A.
      3) Analog, zero- to 5- or 10-V dc.
      4) Analog, 4 to 20 mA, loop powered.

6. Enclosure: NEMA 250, Type 1 enclosure.

2.17 ELECTRICAL POWER DEVICES

A. Transformers:
   1. Transformer shall be sized for the total connected load, plus an additional 25 percent of connected load.
   2. Transformer shall be at least 40 VA.
   3. Transformer shall have both primary and secondary fuses.

B. DC Power Supply:
   1. Manufacturers: Subject to compliance with requirements, provide products from the following:
      a. Functional Devices
   2. Plug-in style suitable for mating with a standard eight-pin octal socket. Include the power supply with a mating mounting socket.
   3. Enclose circuitry in a housing.
   4. Include both line and load regulation to ensure a stable output. To protect both the power supply and the load, power supply shall have an automatic current limiting circuit.
   5. Performance:
a. Output voltage nominally 25-V dc within 5 percent.

b. Output current up to 100 mA.

c. Input voltage nominally 120-V ac, 60 Hz.

d. Load regulation within 0.5 percent from zero- to 100-mA load.

e. Line regulation within 0.5 percent at a 100-mA load for a 10 percent line change.

f. Stability within 0.1 percent of rated volts for 24 hours after a 20-minute warmup.

2.18 UNINTERRUPTABLE POWER SUPPLY (UPS) UNITS

A. 250 through 1000 VA:

1. Manufacturers: Subject to compliance with requirements, provide products from the following:

   a. Functional Devices

2. UPS units shall provide continuous, regulated output power without using their batteries during brown-out, surge, and spike conditions.

3. Load served shall not exceed 75 percent of UPS rated capacity, including power factor of connected loads.

   a. Larger-capacity units shall be provided for systems with larger connected loads.

   b. UPS shall provide five minutes of battery power.

4. Performance:

   a. Input Voltage: Single phase, 120- or 230-V ac, compatible with field power source.

   b. Load Power Factor Range (Crest Factor): 0.65 to 1.0.

   c. Output Voltage: 101- to 132-V ac, while input voltage varies between 89 and 152-V ac.

   d. On Battery Output Voltage: Sine wave.

   e. Inverter overload capacity shall be minimum 150 percent for 30 seconds.

   f. Recharge time shall be a maximum of six hours to 90 percent capacity after full discharge to cutoff.

   g. Transfer Time: 6 ms.

   h. Surge Voltage Withstand Capacity: IEEE C62.41, Categories A and B; 6 kV/200 and 500 A; 100-kHz ringwave.

5. UPS shall be automatic during fault or overload conditions.

6. Unit with integral line-interactive, power condition topology to eliminate all power contaminants.

7. Include front panel with power switch and visual indication of power, battery, fault and temperature.

8. Unit shall include an audible alarm of faults and front panel silence feature.

9. Unit with four NEMA WD 1, NEMA WD 6 Configuration 5-15R receptacles.

10. UPS shall include dry contacts (digital output points) for low battery condition and battery-on (primary utility power failure).

11. Batteries shall be sealed lead-acid type and be maintenance free. Battery replacement shall be front accessible by user without dropping load.

12. Include tower models installed in ventilated cabinets to the particular installation location.

B. 1000 through 3000 VA:

1. Manufacturers: Subject to compliance with requirements, provide products from the following:

   a. Functional Devices
2. UPS units shall provide continuous, regulated output power without using their batteries during brown-out, surge, and spike conditions.

3. Load served shall not exceed 75 percent of UPS rated capacity, including power factor of connected loads.
   a. Larger-capacity units, or multiple units, shall be provided for systems with larger connected loads.
   b. UPS shall provide five minutes of battery power.

4. Performance:
   a. Input Voltage: Single phase, 120-V ac, plus 20 to minus 30 percent.
   b. Power Factor: Minimum 0.97 at full load.
   c. Output Voltage: Single phase, 120-V ac, within 3 percent, steady state with rated output current of 10.0 A, 30.0-A peak.
   d. Inverter overload capacity shall be minimum 150 percent for 30 seconds.
   e. Recharge time shall be a maximum of eight hours to 90 percent capacity.

5. UPS bypass shall be automatic during fault or overload conditions.

6. UPS shall include dry contacts (digital output points) for low battery condition and battery-on (primary utility power failure).

7. Batteries shall be sealed lead-acid type and be maintenance free.

8. Include tower models installed in ventilated cabinets or rack models installed on matching racks, as applicable to the particular installation location and space availability/configuration.

2.19 VARIABLE FREQUENCY DRIVES

A. The Temperature Control Contractor shall furnish all variable speed drives required. Electrical Contractor will install and provide all load side wiring. Temperature Control Contractor shall furnish and install all control wiring.

B. PERFORMANCE CAPABILITIES

1. The Inverter voltage/frequency ratio shall be selectable for reduced torque loads.
2. The Inverter acceleration/deceleration time shall be adjustable from 1 to 120 seconds.
3. The Inverter frequency setting signal choices shall include 0-5 VDC, 0-10 VDC, 4-20 mA.
4. The Inverter shall have a minimum the following protective features with an alarm display indication:
   a. Overcurrent Shut-Off
   b. Regenerative Overvoltage
   c. Electronic Thermal Protector
   d. Heatsink Overheat
   e. Instantaneous Power Failure
   f. Ground Fault

5. The following operator controls shall be provided as a minimum:
   a. Hand/Off/Auto Switch
   b. Local/Remote Switch
   c. Frequency Setting Speed Pot
   d. Frequency Indication Meter Calibrated in % Speed
   e. Amp Meter
f. Elapsed Time Meter
g. Power On Light
h. VFD Enable Light
i. VFD Fault Light

C. ADDITIONAL OPTIONS REQUIRED

1. INPUT DISCONNECT: The Invertor shall be supplied with a door interlocked input disconnect motor circuit protector. The MCP shall allow trip adjustment sufficient to start the motor across the line in the bypass mode and normally be set at a minimum setting for maximum protection in the VFD mode.

2. BYPASS OPTION: The Invertor shall be supplied with a manual bypass contractor arrangement for transfer to the utility line to operate at constant speed. This option shall be prewired in the same enclosure, including contactors, motor overload VFD/Bypass selector switch and Bypass ON light.

3. AUTO RESTART: The Invertor shall initiate an automatic time delayed restart after recovering from undervoltage or loss of power. The Invertor shall not automatically restart after overcurrent, overvoltage, overtemperature, or any other damaging conditions but shall require a manual restart.

4. FREQUENCY JUMP: The drive shall be supplied with the capability of being field retrofitted with a frequency jump control to avoid operating at a point of resonance with the natural frequency of the machine.

5. RADIO INTERFERENCE FILTER: The drive shall be supplied with the capability of being field retrofitted with a radio interference filter to reduce radio interference noise.

6. LINE REACTORS: Variable frequency drives shall be equipped with input line reactors packaged with the drive. The line reactors shall be 3% impedance reactors manufactured to meet MIL-I-45208 and VDE-0550 standards and shall be UL recognized and CSA certified. Drives using DC bus filters in lieu of line reactors are not acceptable.

D. MANUFACTURER QUALIFICATIONS

1. The drive manufacturer shall have a minimum of 5 years experience in producing Adjustable Frequency Motor Drives of the horsepower and voltage range required.

2. The drive supplier shall have a local authorized service center with spare parts stock. The Service Center shall be able to demonstrate capability of assuring quality service and repair with quick turn around based on local parts stock and technical expertise.

3. The Supplier of the VFD equipment shall be an authorized local dealer or representative of the manufacturer located within 500 miles of the job.

4. Approved Manufacturer are EMC/Mitsubishi FRF2 Series or equal.

E. INSTALLATION

1. Field start-up service shall be provided by an authorized factory service representative. The supplier shall provide warranty and authorized factory service including field start-up and training. A written certificate of the same shall be provided at start-up. Start-up by sales representative is not acceptable.

F. Successful vendor shall supply two bound sets of Operation and Maintenance Manuals. Data shall include installation, operation, maintenance, instructions and wiring.

2.20 CONTROL WIRE AND CABLE

A. Wire: Single conductor control wiring above 24 V.
1. Wire size shall be at least No. 18 AWG.
2. Conductor shall be 7/24 soft annealed copper strand with 2- to 2.5-inch lay.
3. Conductor insulation shall be 600 V, Type THWN or Type THHN, and 90 deg C according to UL 83.
4. Conductor colors shall be black (hot), white (neutral), and green (ground).
5. Furnish wire on spools.

B. Single Twisted Shielded Instrumentation Cable above 24 V:

1. Wire size shall be a minimum No. 18 AWG.
2. Conductors shall be a twisted, 7/24 soft annealed copper strand with a 2- to 2.5-inch lay.
3. Conductor insulation shall have a Type THHN/THWN or Type TFN rating.
4. Shielding shall be 100 percent type, 0.35/0.5-mil aluminum/Mylar tape, helically applied with 25 percent overlap, and aluminum side in with tinned copper drain wire.
5. Outer jacket insulation shall have a 600-V, 90-deg C rating and shall be Type TC cable.
6. For twisted pair, conductor colors shall be black and white. For twisted triad, conductor colors shall be black, red and white.
7. Furnish wire on spools.

C. Single Twisted Shielded Instrumentation Cable 24 V and Less:

1. Wire size shall be a minimum No. 18 AWG.
2. Conductors shall be a twisted, 7/24 soft annealed copper stranding with a 2- to 2.5-inch lay.
3. Conductor insulation shall have a nominal 15-mil thickness, constructed from flame-retardant PVC.
4. Shielding shall be 100 percent type, 1.35-mil aluminum/polymer tape, helically applied with 25 percent overlap, and aluminum side in with tinned copper drain wire.
5. Outer jacket insulation shall have a 300-V, 105-deg C rating and shall be Type PLTC cable.
6. For twisted pair, conductor colors shall be black and white. For twisted triad, conductor colors shall be black, red and white.
7. Furnish wire on spools.

D. LAN and Communication Cable: Comply with DDC system manufacturer requirements for network being installed.

1. Cable shall be plenum rated.
2. Cable shall comply with NFPA 70.
3. Cable shall have a unique color that is different from other cables used on Project.
4. Copper Cable for Ethernet Network:
   a. 100BASE-TX, 1000BASE-T, or 1000BASE-TX.
   b. TIA/EIA 586, Category 5e or Category 6.
   c. Minimum 24 AWG solid.
   d. Shielded Twisted Pair (STP) or Unshielded Twisted Pair (UTP).
   e. Thermoplastic insulated conductors, enclosed in a thermoplastic outer jacket, Class CMP as plenum rated.

2.21 RACEWAYS FOR CONTROL WIRING, CABLING, AND TUBING

A. Metal Conduits, Tubing, and Fittings:

1. Manufacturers: Subject to compliance requirements, provide products from one of the following:
a. AFC Cable Systems, Inc.
b. Allied Tube & Conduit; a part of Atkore International.
c. Anamet Electrical, Inc.
d. Current Technology Inc.
e. Electri-Flex Company.
f. O-Z/Gedney; a brand of Emerson Industrial Automation.
g. Picoma Industries, Inc.
h. Republic Conduit.
i. Robroy Industries.
j. Southwire Company.
k. Western Tube and Conduit Corporation.
l. Wheatland Tube Company.

2. Listing and Labeling: Metal conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

3. GRC: Comply with NEMA ANSI C80.1 and UL 6.

4. ARC: Comply with NEMA ANSI C80.5 and UL 6A.

5. IMC: Comply with NEMA ANSI C80.6 and UL 1242.

6. PVC-Coated Steel Conduit: PVC-coated rigid steel conduit.
   a. Comply with NEMA RN 1.
   b. Coating Thickness: 0.040 inch, minimum.

7. EMT: Comply with NEMA ANSI C80.3 and UL 797.

8. FMC: Comply with UL 1; zinc-coated steel or aluminum.

9. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.

10. Fittings for Metal Conduit: Comply with NEMA ANSI FB 1 and UL 514B.
    a. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 1203 and NFPA 70.
    b. Fittings for EMT:
       1) Material: Steel or die cast.
       2) Type: Setscrew or compression.
    c. Expansion Fittings: PVC or steel to match conduit type, complying with UL 651, rated for environmental conditions where installed, and including flexible external bonding jumper.
    d. Coating for Fittings for PVC-Coated Conduit: Minimum thickness of 0.040 inch, with overlapping sleeves protecting threaded joints.

11. Joint Compound for IMC, GRC, or ARC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.
B. Metal Wireways and Auxiliary Gutters:

1. Manufacturers: Subject to compliance requirements, provide products from one of the following:
   a. Cooper B-Line, Inc.; a division of Cooper Industries.
   b. Hoffman; a brand of Pentair Equipment Protection.
   c. MonoSystems, Inc.
   d. Square D; by Schneider Electric.

2. Description: Sheet metal, complying with UL 870 and NEMA 250, and sized according to NFPA 70.
   a. Metal wireways installed outdoors shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

3. Fittings and Accessories: Include covers, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

4. Wireway Covers: Screw-cover type unless otherwise indicated.

5. Finish: Manufacturer's standard enamel finish.

C. Surface Metal Raceways: Galvanized steel with snap-on covers complying with UL 5. Manufacturer's standard enamel finish in color as selected by Architect or prime coated, ready for field painting.

1. Manufacturers: Subject to compliance requirements, provide products from one of the following:
   a. MonoSystems, Inc.
   b. Panduit Corp.
   c. Wiremold/Legrand.

2.22 CONTROL POWER WIRING AND RACEWAYS

A. Comply with requirements in Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables" electrical power conductors and cables.

B. Comply with requirements in Section 26 05 33 "Raceways and Boxes for Electrical Systems" for electrical power raceways and boxes.

2.23 IDENTIFICATION

A. Control Equipment, Instruments, and Control Devices:

1. Engraved tag bearing unique identification.
   a. Include instruments with unique identification identified by equipment being controlled or monitored, followed by point identification.
2. Letter size shall be as follows: Minimum of 0.25 inch high.
3. Tag shall consist of white lettering on black background.
4. Tag shall be engraved phenolic consisting of three layers of rigid laminate. Top and bottom layers are color-coded black with contrasting white center exposed by engraving through outer layer.
5. Tag shall be fastened with drive pins.
6. Instruments, control devices and actuators with Project-specific identification tags having unique identification numbers following requirements indicated and provided by original manufacturer do not require an additional tag.

B. Valve Tags:
1. Brass tags and brass chains attached to valve.
2. Tags shall be at least 0.5 inches in diameter.
3. Include tag with unique valve identification indicating control influence such as flow, level, pressure, or temperature; followed by location of valve, and followed by three-digit sequential number. For example: TV-1.001.
4. Valves with Project-specific identification tags having unique identification numbers following requirements indicated and provided by original manufacturer do not require an additional tag.

C. Raceway and Boxes:
1. Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."
2. Paint cover plates on junction boxes and conduit same color as the tape banding for conduits. After painting, label cover plate "HVAC Controls," using an engraved phenolic tag.
3. For raceways housing pneumatic tubing, add a phenolic tag labeled "HVAC Instrument Air Tubing."
4. For raceways housing air signal tubing, add a phenolic tag labeled "HVAC Air Signal Tubing."

D. Equipment Warning Labels:
1. Acrylic label with pressure-sensitive adhesive back and peel-off protective jacket.
2. Lettering size shall be at least 14-point type with white lettering on red background.
3. Warning label shall read "CAUTION-Equipment operated under remote automatic control and may start or stop at any time without warning. Switch electric power disconnecting means to OFF position before servicing."
4. Lettering shall be enclosed in a white line border. Edge of label shall extend at least 0.25 inch.

2.24 SOURCE QUALITY CONTROL

A. Product(s) and material(s) will be considered defective if they do not pass tests and inspections.

B. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
1. Verify compatibility with and suitability of substrates.

B. Examine roughing-in for products to verify actual locations of connections before installation.
   1. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.
   2. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.

C. Examine walls, floors, roofs, and ceilings for suitable conditions where product will be installed.

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 DDC SYSTEM INTERFACE WITH OTHER SYSTEMS AND EQUIPMENT

A. Communication Interface to Equipment with Integral Controls:
   1. DDC system shall have communication interface with equipment having integral controls and having a communication interface for remote monitoring or control.
   2. Equipment to Be Connected:
      a. Air-terminal units specified in Section 23 36 00 "Air Terminal Units."
      b. Boilers specified in Section 23 52 16 "Condensing Boilers."
      c. Feedwater equipment specified in Section 23 53 13 "Boiler Feedwater Pumps."
      d. Heat wheels and heat exchangers specified in Section 23 72 00 "Air-to-Air Energy Recovery Equipment."
      e. Dedicated outdoor-air units specified in Section 23 74 33 "Dedicated Outdoor-Air Units."
      f. Package terminal air-conditioners specified in Section 23 81 13 "Packaged Terminal Air-Conditioners."
      g. Variable-frequency controllers specified in Section 26 29 23 "Variable-Frequency Motor Controllers."
      h. Generator sets specified in Section 26 32 13 "Engine Generators."
      i. UPS specified in Section 26 33 53 "Static Uninterruptible Power Supply."
      j. See drawings for further requirements.

B. Communication Interface to Other Building Systems:
   1. DDC system shall have a communication interface with systems having a communication interface.
   2. Systems to Be Connected:
      a. See drawings for further requirements.

3.3 CONTROL DEVICES FOR INSTALLATION BY INSTALLERS

A. Deliver selected control devices, specified in indicated HVAC instrumentation and control device Sections, to identified equipment and systems manufacturers for factory installation and to identified installers for field installation.
B. Deliver the following to duct fabricator and Installer for installation in ductwork. Include installation instructions to Installer and supervise installation for compliance with requirements.

1. DDC control dampers, which are specified in Section 23 09 23.12 "DDC Control Dampers."
2. Airflow sensors and switches, which are specified in Section 23 09 23.14 "Flow Instruments."
3. Pressure sensors, which are specified in Section 23 09 23.23 "Pressure Instruments."

C. Deliver the following to plumbing and HVAC piping installers for installation in piping. Include installation instructions to Installer and supervise installation for compliance with requirements.

1. DDC control valves, which are specified in Section 23 09 23.11 "Control Valves."
2. Pipe-mounted flow meters, which are specified in Section 23 09 23.14 "Flow Instruments."
3. Pipe-mounted sensors, switches and transmitters. Flow meters are specified in Section 23 09 23.14 "Flow Instruments." Liquid and steam temperature sensors, switches, and transmitters are specified in Section 23 09 23.27 "Temperature Instruments."
4. Tank-mounted sensors, switches and transmitters. Pressure sensors, switches, and transmitters are specified in Section 23 09 23.23 "Pressure Instruments." Liquid and steam temperature sensors, switches, and transmitters are specified in Section 23 09 23.27 "Temperature Instruments."
5. Pipe- and tank-mounted thermowells. Liquid and steam thermowells are specified in Section 23 09 23.27 "Temperature Instruments."

3.4 GENERAL INSTALLATION REQUIREMENTS

A. Install products to satisfy more stringent of all requirements indicated.

B. Install products level, plumb, parallel, and perpendicular with building construction.

C. Support products, tubing, piping wiring and raceways. Brace products to prevent lateral movement and sway or a break in attachment.

D. If codes and referenced standards are more stringent than requirements indicated, comply with requirements in codes and referenced standards.

E. Fabricate openings and install sleeves in ceilings, floors, roof, and walls required by installation of products. Before proceeding with drilling, punching, and cutting, check for concealed work to avoid damage. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

F. Firestop penetrations made in fire-rated assemblies. Comply with requirements in Section 07 84 13 "Penetration Firestopping."

G. Seal penetrations made in acoustically rated assemblies. Comply with requirements in Section 07 92 00 "Joint Sealants."

H. Welding Requirements:

1. Restrict welding and burning to supports and bracing.
2. No equipment shall be cut or welded without approval. Welding or cutting will not be approved if there is risk of damage to adjacent Work.
3. Welding, where approved, shall be by inert-gas electric arc process and shall be performed by qualified welders according to applicable welding codes.
4. If requested on-site, show satisfactory evidence of welder certificates indicating ability to perform welding work intended.
I. Fastening Hardware:
   1. Stillson wrenches, pliers, and other tools that damage surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening fasteners.
   2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
   3. Lubricate threads of bolts, nuts and screws with graphite and oil before assembly.

J. If product locations are not indicated, install products in locations that are accessible and that will permit service and maintenance from floor, equipment platforms, or catwalks without removal of permanently installed furniture and equipment.

K. Corrosive Environments:
   1. Avoid or limit use of materials in corrosive airstreams and environments, including, but not limited to, the following:
      a. Laboratory exhaust-air streams.
      b. Process exhaust-air streams.
   2. When conduit is in contact with a corrosive airstream and environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment. Comply with requirements for installation of raceways and boxes specified in Section 26 05 33 "Raceways and Boxes for Electrical Systems."
   3. Where instruments are located in a corrosive airstream and are not corrosive resistant from manufacturer, field install products in NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.5 GATEWAY INSTALLATION

A. Install gateways if required for DDC system communication interface requirements indicated.

   1. Install gateway(s) required to suit indicated requirements.

B. Test gateway to verify that communication interface functions properly.

3.6 ROUTER INSTALLATION

A. Install routers if required for DDC system communication interface requirements indicated.

   1. Install router(s) required to suit indicated requirements.

B. Test router to verify that communication interface functions properly.

3.7 CONTROLLER INSTALLATION

A. Install controllers in enclosures to comply with indicated requirements.

   B. Connect controllers to field power supply and to UPS units where indicated.
C. Install controller with latest version of applicable software and configure to execute requirements indicated.

D. Test and adjust controllers to verify operation of connected I/O to achieve performance indicated requirements while executing sequences of operation.

E. Installation of Network Controllers:
   1. Quantity and location of network controllers shall be determined by DDC system manufacturer to satisfy requirements indicated.
   2. Install controllers in a protected location that is easily accessible by operators.
   3. Top of controller shall be within 72 inches of finished floor.

F. Installation of Programmable Application Controllers:
   1. Quantity and location of programmable application controllers shall be determined by DDC system manufacturer to satisfy requirements indicated.
   2. Install controllers in a protected location that is easily accessible by operators.
   3. Top of controller shall be within 72 inches of finished floor.

G. Application-Specific Controllers:
   1. Quantity and location of application-specific controllers shall be determined by DDC system manufacturer to satisfy requirements indicated.
   2. For controllers not mounted directly on equipment being controlled, install controllers in a protected location that is easily accessible by operators.

3.8 ENCLOSURES INSTALLATION

A. Install the following items in enclosures, to comply with indicated requirements:
   1. Gateways.
   2. Routers.
   3. Controllers.
   4. Electrical power devices.
   5. UPS units.
   6. Relays.
   7. Accessories.
   8. Instruments.
   9. Actuators

B. Attach wall-mounted enclosures to wall using the following types of steel struts:
   1. For NEMA 250, Enclosures: Use galvanized-steel strut and hardware.
   2. For NEMA 250, Enclosures and Enclosures Located Outdoors: Use stainless-steel strut and hardware.
   3. Install plastic caps on exposed cut edges of strut.

C. Align top or bottom of adjacent enclosures of like size.

D. Install floor-mounted enclosures located on concrete housekeeping pads. Attach enclosure legs using steel anchors.
E. Install continuous and fully accessible wireways to connect conduit, wire, and cable to multiple adjacent enclosures. Wireway used for application shall have protection equal to NEMA 250 rating of connected enclosures.

3.9 ELECTRIC POWER CONNECTIONS

A. Connect electrical power to DDC system products requiring electrical power connections.

B. Design of electrical power to products not indicated with electric power is delegated to DDC system provider and installing trade. Work shall comply with NFPA 70 and other requirements indicated.

C. Comply with requirements in Section 26 28 16 "Enclosed Switches and Circuit Breakers" for electrical power circuit breakers.

D. Comply with requirements in Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables" for electrical power conductors and cables.

E. Comply with requirements in Section 26 05 33 "Raceways and Boxes for Electrical Systems" for electrical power raceways and boxes.

3.10 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements in Section 26 05 53 "Identification for Electrical Systems" for identification products and installation.

B. Install engraved phenolic nameplate with unique identification on face for each of the following:

1. Operator workstation.
2. Printer.
3. Gateway.
4. Router.
5. DDC controller.
7. Electrical power device.
8. UPS unit.

C. Install engraved phenolic nameplate with unique instrument identification on face of each instrument connected to a DDC controller.

D. Install engraved phenolic nameplate with identification on face of each control damper and valve actuator connected to a DDC controller.

E. Where product is installed above accessible tile ceiling, also install matching engraved phenolic nameplate with identification on face of ceiling grid located directly below.

F. Where product is installed above an inaccessible ceiling, also install engraved phenolic nameplate with identification on face of access door directly below.

G. Warning Labels:
1. Shall be permanently attached to equipment that can be automatically started by DDC control system.
2. Shall be located in highly visible location near power service entry points.

3.11 NETWORK INSTALLATION

A. Install copper cable when connecting between the following network devices located in same building:
   1. Operator workstations.
   2. Operator workstations and network controllers.
   3. Network controllers.

B. Install copper cable when connecting between the following:
   1. Gateways.
   2. Gateways and network controllers or programmable application controllers.
   3. Routers.
   4. Routers and network controllers or programmable application controllers.
   5. Network controllers and programmable application controllers.
   6. Programmable application controllers.
   7. Programmable application controllers and application-specific controllers.

C. Install network cable in continuous raceway.
   1. Where indicated on Drawings, cable trays may be used for copper cable in lieu of conduit.

3.12 NETWORK NAMING AND NUMBERING

A. Coordinate with Owner and provide unique naming and addressing for networks and devices.

B. ASHRAE 135 Networks:
   1. MAC Address:
      a. Every network device shall have an assigned and documented MAC address unique to its network.
      b. Ethernet Networks: Document MAC address assigned at its creation.
      c. ARCNET or MS/TP networks: Assign from 00 to 64.
   2. Network Numbering:
      a. Assign unique numbers to each new network.
      b. Provide ability for changing network number through device switches or operator interface.
      c. DDC system, with all possible connected LANs, can contain up to 65,534 unique networks.
   3. Device Object Identifier Property Number:
      a. Assign unique device object identifier property numbers or device instances for each device network.
      b. Provide for future modification of device instance number by device switches or operator interface.
c. LAN shall support up to 4,194,302 unique devices.

4. Device Object Name Property Text:
   a. Device object name property field shall support 32 minimum printable characters.
   b. Assign unique device "Object Name" property names with plain-English descriptive names for each device.
      1) Example 1: Device object name for device controlling boiler plant at Building 1000 would be "HW System B1000."
      2) Example 2: Device object name for a VAV terminal unit controller could be "VAV unit 102".

5. Object Name Property Text for Other Than Device Objects:
   a. Object name property field shall support 32 minimum printable characters.
   b. Assign object name properties with plain-English names descriptive of application.
      1) Example 1: "Zone 1 Temperature."
      2) Example 2 "Fan Start and Stop."

6. Object Identifier Property Number for Other Than Device Objects:
   a. Assign object identifier property numbers according to Drawings or tables indicated.
   b. If not indicated, object identifier property numbers may be assigned at Installer's discretion but must be approved by Owner in advance, be documented and be unique for like object types within device.

3.13 CONTROL WIRE, CABLE AND RACEWAYS INSTALLATION

A. Comply with NECA 1.

B. Comply with TIA 568-C.1.

C. Wiring Method: Install cables in raceways and cable trays except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used. Conceal raceway and cables except in unfinished spaces.
   1. Install plenum cable in environmental air spaces, including plenum ceilings.
   2. Comply with requirements for cable trays specified in Section 26 05 36 "Cable Trays for Electrical Systems."
   3. Comply with requirements for raceways and boxes specified in Section 26 05 33 "Raceways and Boxes for Electrical Systems."

D. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

E. Field 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.

F. Conduit Installation:
   1. Install conduit expansion joints where conduit runs exceed 200 feet, and conduit crosses building expansion joints.
2. Coordinate conduit routing with other trades to avoid conflicts with ducts, pipes and equipment and service clearance.
3. Maintain at least 3-inch separation where conduits run axially above or below ducts and pipes.
4. Limit above-grade conduit runs to 100 feet without pull or junction box.
5. Do not install raceways or electrical items on any "explosion-relief" walls, or rotating equipment.
6. Do not fasten conduits onto the bottom side of a metal deck roof.
7. Flexible conduit is permitted only where flexibility and vibration control is required.
8. Limit flexible conduit to 3 feet long.
9. Conduit shall be continuous from outlet to outlet, from outlet to enclosures, pull and junction boxes, and shall be secured to boxes in such manner that each system shall be electrically continuous throughout.
10. Direct bury conduits underground or install in concrete-encased duct bank where indicated.
   a. Use rigid, nonmetallic, Schedule 80 PVC.
   b. Provide a burial depth according to NFPA 70, but not less than 24 inches.
11. Secure threaded conduit entering an instrument enclosure, cabinet, box, and trough, with a locknut on outside and inside, such that conduit system is electrically continuous throughout. Provide a metal bushing on inside with insulated throats. Locknuts shall be the type designed to bite into the metal or, on inside of enclosure, shall have a grounding wedge lug under locknut.
12. Conduit box-type connectors for conduit entering enclosures shall have an insulated throat.
13. Connect conduit entering enclosures in wet locations with box-type connectors or with watertight sealing locknuts or other fittings.
14. Offset conduits where entering surface-mounted equipment.
15. Seal conduit runs used by sealing fittings to prevent the circulation of air for the following:
   a. Conduit extending from interior to exterior of building.
   b. Conduit extending into pressurized duct and equipment.
   c. Conduit extending into pressurized zones that are automatically controlled to maintain different pressure set points.

G. Wire and Cable Installation:
1. Cables serving a common system may be grouped in a common raceway. Install control wiring and cable in separate raceway from power wiring. Do not group conductors from different systems or different voltages.
2. Install cables with protective sheathing that is waterproof and capable of withstanding continuous temperatures of 90 deg C with no measurable effect on physical and electrical properties of cable.
   a. Provide shielding to prevent interference and distortion from adjacent cables and equipment.
3. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
4. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIMM, "Cabling Termination Practices" Chapter. Install lacing bars and distribution spools.
5. UTP Cable Installation:
   a. Comply with TIA 568-C.2.
   b. Do not untwist UTP cables more than 1/2 inch from the point of termination, to maintain cable geometry.
6. Installation of Cable Routed Exposed under Raised Floors:
a. Install plenum-rated cable only.

b. Install cabling after the flooring system has been installed in raised floor areas.

c. Coil cable 6 feet long not less than 12 inches in diameter below each feed point.

7. Identify each wire on each end and at each terminal with a number-coded identification tag. Each wire shall have a unique tag.

8. Provide strain relief.

9. Terminate wiring in a junction box.

a. Clamp cable over jacket in junction box.

b. Individual conductors in the stripped section of the cable shall be slack between the clamping point and terminal block.

10. Terminate field wiring and cable not directly connected to instruments and control devices having integral wiring terminals using terminal blocks.

11. Install signal transmission components according to IEEE C2, REA Form 511a, NFPA 70, and as indicated.

12. Keep runs short. Allow extra length for connecting to terminal boards. Do not bend flexible coaxial cables in a radius less than 10 times the cable OD. Use sleeves or grommets to protect cables from vibration at points where they pass around sharp corners and through penetrations.

13. Ground wire shall be copper and grounding methods shall comply with IEEE C2. Demonstrate ground resistance.

14. Wire and cable shall be continuous from terminal to terminal without splices.

15. Use insulated spade lugs for wire and cable connection to screw terminals.

16. Use shielded cable to transmitters.

17. Use shielded cable to temperature sensors.

18. Perform continuity and meager testing on wire and cable after installation.

19. Do not install bruised, kinked, scored, deformed, or abraded wire and cable. Remove and discard wire and cable if damaged during installation, and replace it with new cable.

20. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.

21. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.

22. Protection from Electro-Magnetic Interference (EMI): Provide installation free of (EMI). As a minimum, comply with the following requirements:

a. Comply with BICSI TDMM and TIA 569-C for separating unshielded cable from potential EMI sources, including electrical power lines and equipment.

b. Separation between open cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:

1) Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches.

2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches.


c. Separation between cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:

1) Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches.

2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches.


d. Separation between cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:

1) Electrical Equipment Rating Less Than 2 kVA: No requirement.
2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches.

e. Separation between Cables and Electrical Motors and Transformers, 5 kVA or 5 HP and Larger: A minimum of 48 inches.
f. Separation between Cables and Fluorescent Fixtures: A minimum of 5 inches.

3.14 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and installations, including connections.

C. Perform the following tests and inspections:
   1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
   2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
   3. Testing of Pneumatic and Air-Signal Tubing:
      a. Test for leaks and obstructions.
      b. Disconnect each pipe and tubing line before a test is performed, and blowout dust, dirt, trash, condensate and other foreign materials with compressed air. Use commercially pure compressed air or nitrogen as distributed in gas cylinders. Air from an oil-free compressor with an air dryer is an acceptable alternative for the test.
      c. After foreign matter is expelled and line is free from obstructions, plug far end of tubing run.
      d. Connect a pressure source to near end of run with a needle valve between air supply and tubing run.
      e. Connect a pressure gage accurate to within 0.5 percent of test between the shutoff needle valve and tubing run under test.
      f. For system pressures above 30 psig, apply a pressure of 1.5 times operating pressure. Record pressure in tubing run every 10 minutes for one hour. Allowable drop in pressure in one-hour period shall not exceed 1 psig.
      g. For system pressures 30 psig and below, apply a pressure of 2.0 times operating pressure to piping and tubing run. Record pressure in tubing run every 5 minutes for one hour. Allowable drop in pressure in one-hour period shall not exceed 0.5 psig.

D. Testing:
   1. Perform preinstallation, in-progress, and final tests, supplemented by additional tests, as necessary.
   2. Preinstallation Cable Verification: Verify integrity and serviceability for new cable lengths before installation. This assurance may be provided by using vendor verification documents, testing, or other methods. As a minimum, furnish evidence of verification for cable attenuation and bandwidth parameters.
   3. In-Progress Testing: Perform standard tests for correct pair identification and termination during installation to ensure proper installation and cable placement. Perform tests in addition to those specified if there is any reason to question condition of material furnished and installed. Testing accomplished is to be documented by agency conducting tests. Submit test results for Project record.
   4. Final Testing: Perform final test of installed system to demonstrate acceptability as installed. Testing shall be performed according to a test plan supplied by DDC system manufacturer.
Defective Work or material shall be corrected and retested. As a minimum, final testing for cable system, including spare cable, shall verify conformance of attenuation, length, and bandwidth parameters with performance indicated.

5. Test Equipment: Use a fiber-optic time domain reflectometer for testing of length and optical connectivity.

6. Test Results: Record test results and submit copy of test results for Project record.

3.15 DDC SYSTEM I/O CHECKOUT PROCEDURES

A. Check installed products before continuity tests, leak tests and calibration.

B. Check instruments for proper location and accessibility.

C. Check instruments for proper installation on direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.

D. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material and support.

E. For pneumatic products, verify that air supply for each product is properly installed.

F. Control Damper Checkout:

1. Verify that control dampers are installed correctly for flow direction.
2. Verify that proper blade alignment, either parallel or opposed, has been provided.
3. Verify that damper frame attachment is properly secured and sealed.
4. Verify that damper actuator and linkage attachment is secure.
5. Verify that actuator wiring is complete, enclosed and connected to correct power source.
6. Verify that damper blade travel is unobstructed.

G. Control Valve Checkout:

1. For pneumatic valves, verify that pressure gages are provided in each air line to valve actuator and positioner.
2. Verify that control valves are installed correctly for flow direction.
3. Verify that valve body attachment is properly secured and sealed.
4. Verify that valve actuator and linkage attachment is secure.
5. Verify that actuator wiring is complete, enclosed and connected to correct power source.
6. Verify that valve ball, disc or plug travel is unobstructed.
7. After piping systems have been tested and put into service, but before insulating and balancing, inspect each valve for leaks. Adjust or replace packing to stop leaks. Replace the valve if leaks persist.

H. Instrument Checkout:

1. Verify that instrument is correctly installed for location, orientation, direction and operating clearances.
2. Verify that attachment is properly secured and sealed.
3. Verify that conduit connections are properly secured and sealed.
4. Verify that wiring is properly labeled with unique identification, correct type and size and is securely attached to proper terminals.
5. Inspect instrument tag against approved submittal.
6. For instruments with tubing connections, verify that tubing attachment is secure and isolation valves have been provided.
7. For flow instruments, verify that recommended upstream and downstream distances have been maintained.
8. For temperature instruments:
   a. Verify sensing element type and proper material.
   b. Verify length and insertion.

3.16 DDC SYSTEM I/O ADJUSTMENT, CALIBRATION AND TESTING:
A. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
B. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
C. For each analog instrument, make a three-point test of calibration for both linearity and accuracy.
D. Equipment and procedures used for calibration shall comply with instrument manufacturer's written instructions.
E. Provide diagnostic and test equipment for calibration and adjustment.
F. Field instruments and equipment used to test and calibrate installed instruments shall have accuracy at least twice the instrument accuracy being calibrated. An installed instrument with an accuracy of 1 percent shall be checked by an instrument with an accuracy of 0.5 percent.
G. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.
H. If after calibration indicated performance cannot be achieved, replace out-of-tolerance instruments.
I. Comply with field testing requirements and procedures indicated by ASHRAE's Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements, and to supplement requirements indicated.
J. Analog Signals:
   1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
   2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.
   3. Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistant source.
K. Digital Signals:
   1. Check digital signals using a jumper wire.
   2. Check digital signals using an ohmmeter to test for contact making or breaking.
L. Control Dampers:
   1. Stroke and adjust control dampers following manufacturer's recommended procedure, from 100 percent open to 100 percent closed and back to 100 percent open.
   2. Stroke control dampers with pilot positioners. Adjust damper and positioner following manufacturer's recommended procedure, so damper is 100 percent closed, 50 percent closed and 100 percent open at proper air pressure.
3. Check and document open and close cycle times for applications with a cycle time less than 30 seconds.
4. For control dampers equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

M. Control Valves:
1. Stroke and adjust control valves following manufacturer's recommended procedure, from 100 percent open to 100 percent closed and back to 100 percent open.
2. Stroke control valves with pilot positioners. Adjust valve and positioner following manufacturer's recommended procedure, so valve is 100 percent closed, 50 percent closed and 100 percent open at proper air pressures.
3. Check and document open and close cycle times for applications with a cycle time less than 30 seconds.
4. For control valves equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

N. Meters: Check sensors at zero, 50, and 100 percent of Project design values.

O. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.

P. Switches: Calibrate switches to make or break contact at set points indicated.

Q. Transmitters:
1. Check and calibrate transmitters at zero, 50, and 100 percent of Project design values.
2. Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistant source.

3.17 DDC SYSTEM CONTROLLER CHECKOUT

A. Verify power supply.
1. Verify voltage, phase and hertz.
2. Verify that protection from power surges is installed and functioning.
3. Verify that ground fault protection is installed.
4. If applicable, verify if connected to UPS unit.
5. If applicable, verify if connected to a backup power source.
6. If applicable, verify that power conditioning units, transient voltage suppression and high-frequency noise filter units are installed.

B. Verify that wire and cabling is properly secured to terminals and labeled with unique identification.

C. Verify that spare I/O capacity is provided.

3.18 DDC CONTROLLER I/O CONTROL LOOP TESTS

A. Testing:
1. Test every I/O point connected to DDC controller to verify that safety and operating control set points are as indicated and as required to operate controlled system safely and at optimum performance.
2. Test every I/O point throughout its full operating range.
3. Test every control loop to verify operation is stable and accurate.
4. Adjust control loop proportional, integral and derivative settings to achieve optimum performance while complying with performance requirements indicated. Document testing of each control loop’s precision and stability via trend logs.
5. Test and adjust every control loop for proper operation according to sequence of operation.
6. Test software and hardware interlocks for proper operation. Correct deficiencies.
7. Operate each analog point at the following:
   a. Upper quarter of range.
   b. Lower quarter of range.
   c. At midpoint of range.
8. Exercise each binary point.
9. For every I/O point in DDC system, read and record each value at operator workstation, at DDC controller and at field instrument simultaneously. Value displayed at operator workstation, at DDC controller and at field instrument shall match.
10. Prepare and submit a report documenting results for each I/O point in DDC system and include in each I/O point a description of corrective measures and adjustments made to achieve desired results.

3.19 DDC SYSTEM VALIDATION TESTS

A. Perform validation tests before requesting final review of system. Before beginning testing, first submit Pretest Checklist and Test Plan.

B. After approval of Test Plan, execute all tests and procedures indicated in plan.

C. After testing is complete, submit completed test checklist.

D. Pretest Checklist: Submit the following list with items checked off once verified:

1. Detailed explanation for any items that are not completed or verified.
2. Required mechanical installation work is successfully completed and HVAC equipment is working correctly.
3. HVAC equipment motors operate below full-load amperage ratings.
4. Required DDC system components, wiring, and accessories are installed.
5. Installed DDC system architecture matches approved Drawings.
6. Control electric power circuits operate at proper voltage and are free from faults.
7. Required surge protection is installed.
8. DDC system network communications function properly, including uploading and downloading programming changes.
9. Using BACnet protocol analyzer, verify that communications are error free.
10. Each controller’s programming is backed up.
11. Equipment, products, tubing, wiring cable and conduits are properly labeled.
12. All I/O points are programmed into controllers.
13. Testing, adjusting and balancing work affecting controls is complete.
14. Dampers and actuators zero and span adjustments are set properly.
15. Each control damper and actuator goes to failed position on loss of power.
16. Valves and actuators zero and span adjustments are set properly.
17. Each control valve and actuator goes to failed position on loss of power.
18. Meter, sensor and transmitter readings are accurate and calibrated.
19. Control loops are tuned for smooth and stable operation.
20. View trend data where applicable.
21. Each controller works properly in standalone mode.
22. Safety controls and devices function properly.
23. Interfaces with fire-alarm system function properly.
24. Electrical interlocks function properly.
25. Operator workstations and other interfaces are delivered, all system and database software is installed, and graphic are created.
26. Record Drawings are completed.

E. Test Plan:

1. Prepare and submit a validation test plan including test procedures for performance validation tests.
2. Test plan shall address all specified functions of DDC system and sequences of operation.
3. Explain detailed actions and expected results to demonstrate compliance with requirements indicated.
4. Explain method for simulating necessary conditions of operation used to demonstrate performance.
5. Include a test checklist to be used to check and initial that each test has been successfully completed.
6. Submit test plan documentation 10 business days before start of tests.

F. Validation Test:

1. Verify operating performance of each I/O point in DDC system.
   a. Verify analog I/O points at operating value.
   b. Make adjustments to out-of-tolerance I/O points.
      1) Identify I/O points for future reference.
      2) Simulate abnormal conditions to demonstrate proper function of safety devices.
      3) Replace instruments and controllers that cannot maintain performance indicated after adjustments.

2. Simulate conditions to demonstrate proper sequence of control.
3. Readjust settings to design values and observe ability of DDC system to establish desired conditions.
4. After 24 Hours following Initial Validation Test:
   a. Re-check I/O points that required corrections during initial test.
   b. Identify I/O points that still require additional correction and make corrections necessary to achieve desired results.

5. After 24 Hours of Second Validation Test:
   a. Re-check I/O points that required corrections during second test.
   b. Continue validation testing until I/O point is normal on two consecutive tests.

6. Completely check out, calibrate, and test all connected hardware and software to ensure that DDC system performs according to requirements indicated.
7. After validation testing is complete, prepare and submit a report indicating all I/O points that required correction and how many validation re-tests it took to pass. Identify adjustments made for each test and indicate instruments that were replaced.

G. DDC System Response Time Test:
1. Simulate HLC.
   a. Heavy load shall be an occurrence of 50 percent of total connected binary COV, one-half of which represent an "alarm" condition, and 50 percent of total connected analog COV, one-half of which represent an "alarm" condition, that are initiated simultaneously on a one-time basis.

2. Initiate 10 successive occurrences of HLC and measure response time to typical alarms and status changes.
3. Measure with a timer having at least 0.1-second resolution and 0.01 percent accuracy.
4. Purpose of test is to demonstrate DDC system, as follows:
   a. Reaction to COV and alarm conditions during HLC.
   b. Ability to update DDC system database during HLC.

5. Passing test is contingent on the following:
   a. Alarm reporting at printer beginning no more than 2 (two) seconds after the initiation (time zero) of HLC.
   b. All alarms, both binary and analog, are reported and printed; none are lost.
   c. Compliance with response times specified.

6. Prepare and submit a report documenting HLC tested and results of test including time stamp and print out of all alarms.

H. DDC System Network Bandwidth Test:
1. Test network bandwidth usage on all DDC system networks to demonstrate bandwidth usage under DDC system normal operating conditions and under simulated HLC.
2. To pass, none of DDC system networks shall use more than 70 percent of available bandwidth under normal and HLC operation.

3.20 FINAL REVIEW

A. Submit written request to Architect and Construction Manager when DDC system is ready for final review. Written request shall state the following:
   1. DDC system has been thoroughly inspected for compliance with contract documents and found to be in full compliance.
   2. DDC system has been calibrated, adjusted and tested and found to comply with requirements of operational stability, accuracy, speed and other performance requirements indicated.
   3. DDC system monitoring and control of HVAC systems results in operation according to sequences of operation indicated.
   4. DDC system is complete and ready for final review.

B. Review by Architect and Construction Manager shall be made after receipt of written request. A field report shall be issued to document observations and deficiencies.

C. Take prompt action to remedy deficiencies indicated in field report and submit a second written request when all deficiencies have been corrected. Repeat process until no deficiencies are reported.

D. Should more than two reviews be required, DDC system manufacturer and Installer shall compensate entity performing review for total costs, labor and expenses, associated with third and subsequent
reviews. Estimated cost of each review shall be submitted and approved by DDC system manufacturer and Installer before making the review.

E. Prepare and submit closeout submittals when no deficiencies are reported.

F. A part of DDC system final review shall include a demonstration to parties participating in final review.

1. Provide staff familiar with DDC system installed to demonstrate operation of DDC system during final review.
2. Provide testing equipment to demonstrate accuracy and other performance requirements of DDC system that is requested by reviewers during final review.
3. Demonstration shall include, but not be limited to, the following:
   a. Accuracy and calibration of 10 I/O points randomly selected by reviewers. If review finds that some I/O points are not properly calibrated and not satisfying performance requirements indicated, additional I/O points may be selected by reviewers until total I/O points being reviewed that satisfy requirements equals quantity indicated.
   b. HVAC equipment and system hardwired and software safeties and life-safety functions are operating according to sequence of operation. Up to 10 I/O points shall be randomly selected by reviewers. Additional I/O points may be selected by reviewers to discover problems with operation.
   c. Correct sequence of operation after electrical power interruption and resumption after electrical power is restored for randomly selected HVAC systems.
   d. Operation of randomly selected dampers and valves in normal-on, normal-off and failed positions.
   e. Reporting of alarm conditions for randomly selected alarms, including different classes of alarms, to ensure that alarms are properly received by operators and operator workstations.
   f. Trends, summaries, logs and reports set-up for Project.
   g. For up to three HVAC systems randomly selected by reviewers, use graph trends to show that sequence of operation is executed in correct manner and that HVAC systems operate properly through complete sequence of operation including different modes of operations indicated. Show that control loops are stable and operating at set points and respond to changes in set point of 20 percent or more.
   h. Software's ability to communicate with controllers, operator workstations, uploading and downloading of control programs.
   i. Software's ability to edit control programs off-line.
   j. Data entry to show Project-specific customizing capability including parameter changes.
   k. Step through penetration tree, display all graphics, demonstrate dynamic update, and direct access to graphics.
   l. Execution of digital and analog commands in graphic mode.
   m. Spreadsheet and curve plot software and its integration with database.
   n. Online user guide and help functions.
   o. Multitasking by showing different operations occurring simultaneously on four quadrants of split screen.
   p. System speed of response compared to requirements indicated.
   q. For Each Network and Programmable Application Controller:
      1) Memory: Programmed data, parameters, trend and alarm history collected during normal operation is not lost during power failure.
      2) Operator Interface: Ability to connect directly to each type of digital controller with a portable operator workstation and PDA. Show that maintenance personnel interface tools perform as indicated in manufacturer's technical literature.
3) Standalone Ability: Demonstrate that controllers provide stable and reliable standalone operation using default values or other method for values normally read over network.

4) Electric Power: Ability to disconnect any controller safely from its power source.

5) Wiring Labels: Match control drawings.

6) Network Communication: Ability to locate a controller's location on network and communication architecture matches Shop Drawings.

7) Nameplates and Tags: Accurate and permanently attached to control panel doors, instrument, actuators and devices.

d. For Each Operator Workstation:

1) I/O points lists agree with naming conventions.

2) Graphics are complete.

3) UPS unit, if applicable, operates.

s. Communications and Interoperability: Demonstrate proper interoperability of data sharing, alarm and event management, trending, scheduling, and device and network management. Requirements must be met even if only one manufacturer's equipment is installed.

1) Data Presentation: On each operator workstation, demonstrate graphic display capabilities.

2) Reading of Any Property: Demonstrate ability to read and display any used readable object property of any device on network.

3) Set Point and Parameter Modifications: Show ability to modify set points and tuning parameters indicated.

4) Peer-to-Peer Data Exchange: Network devices are installed and configured to perform without need for operator intervention to implement Project sequence of operation and to share global data.

5) Alarm and Event Management: Alarms and events are installed and prioritized according to Owner. Demonstrate that time delays and other logic are set up to avoid nuisance tripping. Show that operators with sufficient privileges are permitted.

6) Schedule Lists: Schedules are configured for start and stop, mode change, occupant overrides, and night setback as defined in sequence of operations.

7) Schedule Display and Modification: Ability to display any schedule with start and stop times for calendar year. Show that all calendar entries and schedules are modifiable from any connected operator workstation by an operator with sufficient privilege.

8) Archival Storage of Data: Data archiving is handled by operator workstation and server and local trend archiving and display is accomplished.

9) Modification of Trend Log Object Parameters: Operator with sufficient privilege can change logged data points, sampling rate, and trend duration.

10) Device and Network Management:

   a) Display of network device status.

   b) Display of BACnet Object Information.

   c) Silencing devices transmitting erroneous data.

   d) Time synchronization.

   e) Remote device re-initialization.

   f) Backup and restore network device programming and master database(s).

   g) Configuration management of routers.
3.21 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.22 MAINTENANCE SERVICE

A. Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12 months' full maintenance by DDC system manufacturer's authorized service representative. Include monthly preventive maintenance, repair or replacement of worn or defective components, cleaning, calibration and adjusting as required for proper operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

3.23 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for one year.

B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within one year from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.

1. Upgrade Notice: At least 30 days to allow Owner to schedule and access system and to upgrade computer equipment if necessary.

3.24 DEMONSTRATION

A. Engage a factory-authorized service representative with complete knowledge of Project-specific system installed to train Owner's maintenance personnel to adjust, operate, and maintain DDC system.

B. Extent of Training:

1. Base extent of training on scope and complexity of DDC system indicated and training requirements indicated. Provide extent of training required to satisfy requirements indicated even if more than minimum training requirements are indicated.

2. Inform Owner of anticipated training requirements if more than minimum training requirements are indicated.

3. Minimum Training Requirements:

   a. Provide not less than two days of training total.

   b. Stagger training over multiple training classes to accommodate Owner's requirements. All training shall occur before end of warranty period.

   c. Total days of training shall be broken into not more than four separate training classes.

C. Training Documentation:

1. Contractor to submit draft copy of agenda and training documents to Owner for review at least two weeks prior to training date.

2. Provide a copy of the following items for each person that will be attending the training sessions. Coordinate required number with the Owner.
a. Training agenda.
b. Summary of new systems and existing systems affected by this project.
c. Summary of work performed under this project.
d. Control system drawings and sequences of operation.
e. List of important maintenance and trouble-shooting operations for all systems.

3. Provide minimum of 2 copies of following items:
   a. Contract documents including all drawings, specifications, addendums, and change orders.

D. Training Sessions:

1. Assemble at location to be determined by the Owner.
2. Distribute training documentation as indicated above.
3. Provide classroom style training if required for orientation, discussion of new systems and existing systems affected by this project, and other issues appropriate for a classroom format.
4. Visit site and review locations, and perform detailed review of operation and maintenance requirements for current systems.

END OF SECTION 23 09 23
SECTION 23 09 23.11 - CONTROL VALVES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes control valves and actuators for DDC systems.

B. Related Requirements:
   1. Section 23 09 23 "Direct-Digital Control System for HVAC" control equipment and software,
      relays, electrical power devices, uninterruptible power supply units, wire, and cable.
   2. Section 23 09 93 "Sequence of Operations for HVAC Controls" for requirements that relate to
      Section 23 09 23.11.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:
   1. Include diagrams for power, signal, and control wiring.
   2. Include diagrams for pneumatic signal and main air tubing.

C. Delegated-Design Submittal:
   1. Schedule and design calculations for control valves and actuators, including the following:
      a. Flow at project design and minimum flow conditions.
      b. Pressure differential drop across valve at project design flow condition.
      c. Maximum system pressure differential drop (pump close-off pressure) across valve at
         project minimum flow condition.
      d. Design and minimum control valve coefficient with corresponding valve position.
      e. Maximum close-off pressure.
      f. Leakage flow at maximum system pressure differential.
      g. Torque required at worst case condition for sizing actuator.
      h. Actuator selection indicating torque provided.

1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.
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 application.

B. ASME Compliance: Fabricate and label products to comply with ASME Boiler and Pressure Vessel Code where required by authorities having jurisdiction.

C. Ground Fault: Products shall not fail due to ground fault condition when suitably grounded.

D. Determine control valve sizes and flow coefficients by ISA 75.01.01.

E. Control valve characteristics and rangeability shall comply with ISA 75.11.01.

F. Selection Criteria:

1. Control valves shall be suitable for operation at following conditions:
   a. Heat Pump Loop Water: 100 psi 0-150 deg F.
   b. Heating Hot Water: 100 psi 250 deg F.
   c. Steam: 100 psi 300 deg F.

2. Fail positions unless otherwise indicated:
   b. Heating Hot Water: Open.
   c. Steam: Close.

3. Minimum Cv shall be calculated at 10 percent of design flow, with a coincident pressure differential equal to the system design pump head.

4. In water systems, select modulating control valves at terminal equipment for a design Cv based on a pressure drop of 5 psig at design flow unless otherwise indicated.

5. Modulating valve sizes for steam service shall provide a pressure drop at design flow equal to lesser of the following:
   a. 50 percent of the valve inlet pressure.
   b. 50 percent of the absolute steam pressure at the valve inlet.

2.2 BALL-STYLE CONTROL VALVES

A. Ball Valves with Single Port and Characterized Disk:

1. Pressure Rating for NPS 1 and Smaller: Nominal 600 WOG.
2. Pressure Rating for NPS 1-1/2 through NPS 2: Nominal 400 WOG.
4. Process Temperature Range: Zero to 212 deg F.
7. Ball: Chrome-plated brass or bronze or 300 series stainless steel.
CONTROL VALVES

8. Stem and Stem Extension:
   a. Material to match ball.
   b. Blowout-proof design.
   c. Sleeve or other approved means to allow valve to be opened and closed without damaging
      the insulation or the vapor barrier seal.

9. Ball Seats: Reinforced PTFE.
10. Stem Seal: Reinforced PTFE packing ring with a threaded packing ring follower to retain the
     packing ring under design pressure with the linkage removed. Alternative means, such as EPDM
     O-rings, are acceptable if an equivalent cycle endurance can be demonstrated by testing.

B. Ball Valves with Two Ports and Characterized Disk:

1. Pressure Rating for NPS 1 and Smaller: Nominal 600 WOG.
2. Pressure Rating for NPS 1-1/2 through NPS 2: Nominal 400 WOG.
4. Process Temperature Range: Zero to 212 deg F.
5. Body and Tail Piece: Cast bronze ASTM B 61, ASTM B 62, ASTM B 584, or forged brass with
   nickel plating.
7. Ball: Chrome-plated brass or bronze or 300 series stainless steel.
8. Stem and Stem Extension:
   a. Material to match ball.
   b. Blowout-proof design.
   c. Sleeve or other approved means to allow valve to be opened and closed without damaging
      the insulation or the vapor barrier seal.

9. Ball Seats: Reinforced PTFE.
10. Stem Seal: Reinforced PTFE packing ring with a threaded packing ring follower to retain the
     packing ring under design pressure with the linkage removed. Alternative means, such as EPDM
     O-rings, are acceptable if an equivalent cycle endurance can be demonstrated by testing.
12. Flow Characteristics for B-Port: Modified for constant common port flow.

C. Pressure-Independent Ball Valves NPS 2 and Smaller:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the
   following:
   a. Belimo Aircontrols (USA), Inc.
   b. HCI; Hydronics Components Inc.
2. Performance:
   a. Pressure Rating: 600 psig for NPS 1 and 400 psig for NPS 1-1/2 and NPS 2.
   b. Close-off pressure of 200 psig.
   c. Process Temperature Range: Between zero to 212 deg F.
   d. Rangeability: 100 to 1.
3. Integral Pressure Regulator: Located upstream of ball to regulate pressure, to maintain a
   constant pressure differential while operating within a pressure differential range of 5 to 50 psig.
5. Ball: Chrome-plated brass.
7. Stem sleeve or other approved means to allow valve to be opened and closed without damaging field-applied insulation and insulation vapor barrier seal.
8. Ball Seats: Reinforced PTFE.
9. Stem Seal: Reinforced PTFE packing ring stem seal with threaded packing ring follower to retain the packing ring under design pressure with the linkage removed. Alternative means, such as EPDM O-rings, are acceptable if equivalent cycle endurance can be achieved.

2.3 BUTTERFLY-STYLE CONTROL VALVES

A. Commercial-Grade, Two-Way Butterfly Valves:

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

2. Performance:
   a. Bi-directional bubble tight shutoff at 250 psig.
   b. Comply with MSS SP-67 or MSS SP-68.
   c. Rotation: Zero to 90 degrees.
   d. Linear or modified equal percentage flow characteristic.

3. Body: Cast iron ASTM A 126, Class B, ductile iron ASTM A 536 or cast steel ASTM A 216/A 216M WCB fully lugged, suitable for mating to ASME B16.5 flanges.
5. Shaft: 316 or 17-4 PH stainless steel.
7. Shaft Bushings: Reinforced PTFE or stainless steel.
8. Replaceable seat, disc, and shaft bushings.
9. Corrosion-resistant nameplate indicating:
   a. Manufacturer’s name, model number, and serial number.
   b. Body size.
   c. Body and trim materials.
   d. Flow arrow.

B. Commercial-Grade, Three-Way Butterfly Valves:

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

2. Arrangement: Two valves mated to a fabricated tee with interconnecting mechanical linkage.
3. Performance:
   a. Bi-directional bubble tight shutoff at 250 psig.
   b. Comply with MSS SP-67 or MSS SP-68.
   c. Rotation: Zero to 90 degrees.
   d. Linear or modified equal percentage flow characteristic.
4. Body: Cast iron ASTM A 126, Class B, ductile iron ASTM A 536 or cast steel ASTM A 216/A 216M WCB fully lagged, suitable for mating to ASME B16.5 flanges.
7. Seat: Reinforced EPDM or reinforced PTFE seat with retaining ring.
8. Shaft Bushings: Reinforced PTFE or stainless steel.
9. Replaceable seat, disc, and shaft bushings.
10. Corrosion-resistant nameplate indicating:
   a. Manufacturer's name, model number, and serial number.
   b. Body size.
   c. Body and trim materials.
   d. Flow arrow.

2.4 GLOBE-STYLE CONTROL VALVES

A. General Globe-Style Valve Requirements:
1. Globe-style control valve body dimensions shall comply with ISA 75.08.01.
2. Construct the valves to be serviceable from the top.
3. For cage guided valves, trim shall be field interchangeable for different valve flow characteristics, such as equal percentage, linear, and quick opening.
4. Reduced trim for one nominal size smaller shall be available for industrial valves NPS 1 and larger.
5. Replaceable seats and plugs.
6. Furnish each control valve with a corrosion-resistant nameplate indicating the following:
   a. Manufacturer's name, model number, and serial number.
   b. Body size.
   c. Arrow indicating direction of flow.

B. Two-Way Globe Valves NPS 2 and Smaller:
1. Manufacturers: Subject to compliance with requirements, provide products by the following:
   a. Johnson Controls, Inc.
4. End Connections: Threaded.
5. Bonnet: Screwed.
7. Plug: Top guided.
8. Plug, Seat, and Stem: Brass or stainless steel.
9. Process Temperature Range: 35 to 248 deg F.
10. Ambient Operating Temperature: 35 to 150 deg F.
11. Leakage: FCI 70-2, Class IV.

C. Three-Way Globe Valves NPS 2 and Smaller:
1. Manufacturers: Subject to compliance with requirements, provide products by the following:
CONTROL VALVES

a. Johnson Controls, Inc.

2. Globe Style: Mix flow pattern.
4. End Connections: Threaded.
5. Bonnet: Screwing.
7. Plug: Top guided.
8. Plug, Seat, and Stem: Brass or stainless steel.
9. Process Temperature Range: 35 to 248 deg F.
10. Ambient Operating Temperature: 35 to 150 deg F.
11. Leakage: FCI 70-2, Class IV.
13. Linear flow characteristic.

D. Two-Way Globe Valves NPS 2-1/2 to NPS 6:

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

a. Johnson Controls, Inc.

3. Body: Cast iron complying with ASME B61.1, Class 125.
5. Bonnet: Bolted.
7. Plug: Top or bottom guided.
8. Plug, Seat, and Stem: Brass or stainless steel.
10. Leakage: 0.1 percent of maximum flow.
11. Rangeability: Varies with valve size between 6 and 10 to 1.
12. Modified linear flow characteristic.

E. Industrial-Grade Straight-Through Globe Valves NPS 1 and Larger:

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


3. Body: Cast iron or cast steel.
4. End Connections for NPS 2: Threaded.
5. End Connections for NPS 2-1/2 and Larger: Raised face flanged.
8. Plug: Cage guided and unbalanced.
10. Valve Stem: Thread and pin stem to plug.
11. Valve Stem Finish: Polished to 5 microinches rms or less.
13. Process Temperature Range: Zero to 450 deg F.
14. Ambient Operating Temperature: Minus 20 to plus 150 deg F.
15. Leakage: FCI 70-2, Class IV.
2.5 SOLENOID VALVES

A. Manufacturers: Subject to compliance with requirements, provide products by the following:
   1. ASCO Valve, Inc.

B. Description:
   1. Action: Either normally open or normally closed in the event of electrical power failure as required by the application.
   2. Size to close against the system pressure.
   4. Heavy-duty assembly.
   5. Body: Brass or stainless steel.
   6. Seats and Discs: NBR or PTFE.

2.6 ELECTRIC AND ELECTRONIC CONTROL VALVE ACTUATORS

A. Actuators for Hydronic Control Valves: Capable of closing valve against system pump shutoff head.

B. Actuators for Steam Control Valves: Shutoff against 1.5 times steam design pressure.

C. Position indicator and graduated scale on each actuator.

D. Type: Motor operated, with or without gears, electric and electronic.

E. Voltage: Voltage selection delegated to professional designing control system.

F. Deliver torque required for continuous uniform movement of controlled device from limit to limit when operated at rated voltage.

G. Function properly within a range of 85 to 120 percent of nameplate voltage.

H. Construction:
   1. For Actuators Less Than 100 W: Fiber or reinforced nylon gears with steel shaft, copper alloy or nylon bearings, and pressed steel enclosures.
   2. For Actuators from 100 to 400 W: Gears ground steel, oil immersed, shaft hardened steel running in bronze, copper alloy or ball bearings. Operator and gear trains shall be totally enclosed in dustproof cast-iron, cast-steel or cast-aluminum housing.
   3. For Actuators Larger Than 400 W: Totally enclosed reversible induction motors with auxiliary hand crank and permanently lubricated bearings.

I. Field Adjustment:
   1. Spring Return Actuators: Easily switchable from fail open to fail closed in the field without replacement.
   2. Gear Type Actuators: External manual adjustment mechanism to allow manual positioning when the actuator is not powered.

J. Two-Position Actuators: Single direction, spring return or reversing type.
K. Modulating Actuators:
   1. Operation: Capable of stopping at all points across full range, and starting in either direction from any point in range.
   2. Control Input Signal:
      a. Three Point, Tristate, or Floating Point: Clockwise and counter-clockwise inputs. One input drives actuator to open position and other input drives actuator to close position. No signal of either input remains in last position.
      b. Proportional: Actuator drives proportional to input signal and modulates throughout its angle of rotation. Suitable for zero- to 10- or 2- to 10-V dc and 4- to 20-mA signals.

L. Position Feedback:
   1. Equip two-position actuators with limits switches or other positive means of a position indication signal for remote monitoring of open and close position.
   2. Equip modulating actuators with a position feedback through current or voltage signal for remote monitoring.
   3. Provide a position indicator and graduated scale on each actuator indicating open and closed travel limits.

M. Fail-Safe:
   1. Where indicated, provide actuator to fail to an end position.
   2. Internal spring return mechanism to drive controlled device to an end position (open or close) on loss of power.
   3. Batteries, capacitors, and other non-mechanical forms of fail-safe operation are acceptable only where uniquely indicated.

N. Integral Overload Protection:
   1. Provide against overload throughout the entire operating range in both directions.
   2. Electronic overload, digital rotation sensing circuitry, mechanical end switches, or magnetic clutches are acceptable methods of protection.

O. Valve Attachment:
   1. Unless otherwise required for valve interface, provide an actuator designed to be directly coupled to valve shaft without the need for connecting linkages.
   2. Attach actuator to valve drive shaft in a way that ensures maximum transfer of power and torque without slippage.
   3. Bolt and set screw method of attachment is acceptable only if provided with at least two points of attachment.

P. Temperature and Humidity:
   1. Temperature: Suitable for operating temperature range encountered by application with minimum operating temperature range of minus 20 to plus 120 deg F.
   2. Humidity: Suitable for humidity range encountered by application; minimum operating range shall be from 5 to 95 percent relative humidity, non-condensing.

Q. Enclosure:
   1. Suitable for ambient conditions encountered by application.
2. NEMA 250, Type 2 for indoor and protected applications.
3. NEMA 250, Type 4 or Type 4X for outdoor and unprotected applications.
4. Provide actuator enclosure with heater and control where required by application.

R. Stroke Time:
1. Operate valve from fully closed to fully open within 60 seconds.
2. Operate valve from fully open to fully closed within 90 seconds.
3. Move valve to failed position within 30 seconds.
4. Select operating speed to be compatible with equipment and system operation.

S. Sound:
1. Spring Return: 62 dBA.
2. Non-Spring Return: 45 dBA.

PART 3 - EXECUTION

3.1 CONTROL VALVE APPLICATIONS

A. Control Valves:
1. Select from valves specified in "Control Valves" Article to achieve performance requirements and characteristics indicated while subjected to full range of system operation encountered.
2. Heating Hot Water System, Two-Way Applications Controlled by Flow: Ball valves with single port and characterized disk.

3.2 INSTALLATION, GENERAL

A. Furnish and install products required to satisfy most stringent requirements indicated.

B. Install products level, plumb, parallel, and perpendicular with building construction.

C. Properly support instruments, tubing, piping, wiring, and conduits to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to a seismic force.

D. Provide ceiling, floor, roof, and wall openings and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

E. Firestop penetrations made in fire-rated assemblies and seal penetrations made in acoustically rated assemblies.

F. Fastening Hardware:
1. Stillson wrenches, pliers, and other tools that will cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not over-stress threads by excessive force or by oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

G. Install products in locations that are accessible and that will permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

H. Corrosive Environments:

1. Use products that are suitable for environment to which they will be subjected.
2. If possible, avoid or limit use of materials in corrosive environments, including, but not limited to, the following:
   a. Laboratory exhaust airstreams.
   b. Process exhaust airstreams.
3. Use Type 316 stainless-steel tubing and fittings when in contact with a corrosive environment.
4. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
5. Where control devices are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.3 ELECTRIC POWER

A. Furnish and install electrical power to products requiring electrical connections.
B. Furnish and install circuit breakers. Comply with requirements in Section 26 28 16 "Enclosed Switches and Circuit Breakers."
C. Furnish and install power wiring. Comply with requirements in Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."
D. Furnish and install raceways. Comply with requirements in Section 26 05 33 "Raceways and Boxes for Electrical Systems."

3.4 CONTROL VALVES

A. Install pipe reducers for valves smaller than line size. Position reducers as close to valve as possible but at distance to avoid interference and impact to performance. Install with manufacturer-recommended clearance.
B. Install flanges or unions to allow drop-in and -out valve installation.
C. Where indicated, install control valve with three-valve bypass manifold to allow for control valve isolation and removal without interrupting system flow by providing manual throttling valve in bypass pipe.
D. Install drain valves in piping upstream and downstream of each control valve installed in a three-valve manifold and for each control valve larger than NPS 2.
E. Install pressure temperature taps in piping upstream and downstream of each control valve larger than NPS 1.

F. Valve Orientation:
   1. Where possible, install globe and ball valves installed in horizontal piping with stems upright and not more than 15 degrees off of vertical, not inverted.
   2. Install valves in a position to allow full stem movement.
   3. Where possible, install butterfly valves that are installed in horizontal piping with stems in horizontal position and with low point of disc opening with direction of flow.

G. Clearance:
   1. Locate valves for easy access and provide separate support of valves that cannot be handled by service personnel without hoisting mechanism.
   2. Install valves with at least 12 inches of clear space around valve and between valves and adjacent surfaces.

H. Threaded Valves:
   1. Note internal length of threads in valve ends, and proximity of valve internal seat or wall, to determine how far pipe should be threaded into valve.
   2. Align threads at point of assembly.
   3. Apply thread compound to external pipe threads, except where dry seal threading is specified.
   4. Assemble joint, wrench tight. Apply wrench on valve end as pipe is being threaded.

I. Flanged Valves:
   1. Align flange surfaces parallel.
   2. Assemble joints by sequencing bolt tightening to make initial contact of flanges and gaskets as flat and parallel as possible. Use suitable lubricants on bolt threads. Tighten bolts gradually and uniformly with a torque wrench.

J. Connect electrical devices and components to electrical grounding system. Comply with requirements in Section 26 05 26 "Grounding and Bonding for Electrical Systems."

K. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

L. Install engraved phenolic nameplate with valve identification on valve.

3.5 CHECKOUT PROCEDURES

A. Control Valve Checkout:
   1. Check installed products before continuity tests, leak tests, and calibration.
   2. Check valves for proper location and accessibility.
   3. Check valves for proper installation for direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.
   4. For pneumatic products, verify air supply for each product is properly installed.
5. For pneumatic valves, verify that pressure gauges are provided in each air line to valve actuator and positioner.
6. Verify that control valves are installed correctly for flow direction.
7. Verify that valve body attachment is properly secured and sealed.
8. Verify that valve actuator and linkage attachment are secure.
9. Verify that actuator wiring is complete, enclosed, and connected to correct power source.
10. Verify that valve ball, disc, and plug travel are unobstructed.
11. After piping systems have been tested and put into service, but before insulating and balancing, inspect each valve for leaks. Adjust or replace packing to stop leaks. Replace the valve if leaks persist.

3.6 ADJUSTMENT, CALIBRATION, AND TESTING

A. Stroke and adjust control valves following manufacturer’s recommended procedure, from 100 percent open to 100 percent closed back to 100 percent open.

B. Stroke control valves with pilot positioners. Adjust valve and positioner following manufacturer's recommended procedure, so valve is 100 percent closed, 50 percent closed, and 100 percent open at proper air pressures.

C. Check and document open and close cycle times for applications with a cycle time of less than 30 seconds.

D. For control valves equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

END OF SECTION 23 09 23.11
SECTION 23 09 23.12 - CONTROL DAMPERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes control dampers and actuators for DDC systems.

B. Related Requirements:
   1. Section 23 09 23 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.
   2. Section 23 09 93 "Sequence of Operations for HVAC Controls" for requirements that relate to Section 23 09 23.12.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Include diagrams for power, signal, and control wiring.

C. Delegated-Design Submittal:
   1. Schedule and design calculations for control dampers and actuators, including the following.
      a. Flow at project design and minimum flow conditions.
      b. Face velocity at project design and minimum airflow conditions.
      c. Pressure drop across damper at project design and minimum airflow conditions.
      d. AMCA 500D damper installation arrangement used to calculate and schedule pressure drop, as applicable to installation.
      e. Maximum close-off pressure.
      f. Leakage airflow at maximum system pressure differential (fan close-off pressure).
      g. Torque required at worst case condition for sizing actuator.
      h. Actuator selection indicating torque provided.

1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

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 application.
B. ASME Compliance: Fabricate and label products to comply with ASME Boiler and Pressure Vessel Code where required by authorities having jurisdiction.

C. Ground Fault: Products shall not fail due to ground fault condition when suitably grounded.

D. Selection Criteria:
   1. Select modulating dampers for a pressure drop of 2 percent of fan total static pressure unless otherwise indicated.

2.2 RECTANGULAR CONTROL DAMPERS

A. General Requirements:
   1. Unless otherwise indicated, use parallel blade configuration for two-position control, equipment isolation service, and when mixing two airstreams. For other applications, use opposed blade configuration.
   2. Factory assemble multiple damper sections to provide a single damper assembly of size required by the application.

B. Rectangular Dampers with Aluminum Airfoil Blades:
   1. Performance:
      a. Leakage: AMCA 511, Class 1A. Leakage shall not exceed 3 cfm/sq. ft. against 1-in. wg differential static pressure.
      b. Pressure Drop: 0.05-in. wg at 1500 fpm across a 24-by-24-inch damper when tested according to AMCA 500-D, figure 5.3.
      c. Velocity: Up to 6000 fpm.
      d. Temperature: Minus 40 to plus 185 deg F.
      e. Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length.
      f. Damper shall have AMCA seal for both air leakage and air performance.
   2. Construction:
      a. Frame:
         1) Material: ASTM B 211, Alloy 6063 T5 extruded-aluminum profiles,0.07 inch thick.
         2) Hat-shaped channel with integral flange(s). Mating face shall be a minimum of 1 inch.
         3) Width not less than 5 inches.
      b. Blades:
         1) Hollow, airfoil, extruded aluminum.
         2) Parallel or opposed blade configuration as required by application.
         3) Material: ASTM B 211, Alloy 6063 T5 aluminum, 0.07 inch thick.
         4) Width not to exceed 6 inches.
         5) Length as required by close-off pressure, not to exceed 48 inches.
      c. Seals:
1) Blades: Replaceable, mechanically attached extruded silicone, vinyl, or plastic composite.
2) Jambs: Stainless steel, compression type.

d. Axles: 0.5-inch-diameter stainless steel, mechanically attached to blades.
e. Bearings:
   1) Molded synthetic or stainless-steel sleeve mounted in frame.
   2) Where blade axles are installed in vertical position, provide thrust bearings.

f. Linkage:
   1) Concealed in frame.
   2) Constructed of aluminum and stainless steel.
   3) Hardware: Stainless steel.

g. Transition:
   1) For round and flat oval duct applications, provide damper assembly with integral transitions to mate to adjoining field connection.
   2) Factory mount damper in a sleeve with a close transition to mate to field connection.
   3) Damper size and sleeve shall be connection size plus 2 inches.
   4) Sleeve length shall be not less than 12 inches for dampers without jackshafts and shall be not less than 16 inches for dampers with jackshafts.
   5) Sleeve material shall match adjacent duct.

h. Additional Corrosion Protection for Corrosive Environments:
   1) Provide anodized finish for aluminum surfaces in contact with airstream. Anodized finish shall be a minimum of 0.0007 inch thick.
   2) Axles, damper linkage, and hardware shall be constructed of Type 316L stainless steel.

3. Airflow Measurement:
   a. Where indicated, provide damper assembly with integral airflow monitoring.
   b. Zero- to 10-V dc or 4- to 20-mA scaled output signal for remote monitoring of actual airflow.
   c. Accuracy shall be within 5 percent of the actual flow rate between the range of minimum and design airflow. For applications with a large variation in range between the minimum and design airflow, configure the damper sections and flow measurement assembly as required to comply with the stated accuracy over the entire modulating range.
   d. Provide a straightening device as part of the flow measurement assembly to achieve the specified accuracy with configuration indicated.
   e. Suitable for operation in untreated and unfiltered air.
   f. Provide temperature and altitude compensation and correction to maintain accuracy over temperature range encountered at site altitude.
   g. Provide automatic zeroing feature.

4. Airflow Control:
   a. Where indicated, provide damper assembly with integral airflow measurement and control.
   b. A factory-furnished and -calibrated controller shall be programmed, in nonvolatile EPROM, with application-specific airflow set point and range.
   c. The controller and actuator shall communicate to control the desired airflow.
d. The controller shall receive a zero- to 10-V dc input signal and report a zero- to 20-mA output signal that is proportional to the airflow.

e. Airflow measurement and control range shall be suitable for operation between 150 to 2000 fpm.

f. Ambient Operating Temperature Range: Minus 40 to plus 140 deg F.

g. Ambient Operating Humidity Range: 5 to 95 percent relative humidity, non-condensing.

h. Provide unit with control transformer rated for not less than 85 VA. Provide transformer with primary and secondary protection and primary disconnecting means. Coordinate requirements with field power connection.

i. Provide screw terminals for interface to field wiring.

j. Factory mount electronics within a NEMA 250, Type 1 painted steel enclosure.

C. Rectangular Dampers with Steel Airfoil Blades:

1. Performance:

a. Leakage: AMCA 511, Class 1A. Leakage shall not exceed 3 cfm/sq. ft. against 1-in. wg differential static pressure.

b. Pressure Drop: 0.06-in. wg at 1500 fpm across a 24-by-24-inch damper when tested according to AMCA 500-D, figure 5.3.

c. Velocity: Up to 6000 fpm.

d. Temperature: Minus 40 to plus 185 deg F.

e. Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length.

f. Damper shall have AMCA seal for both air leakage and air performance.

2. Construction:

a. Frame:

   1) Material: ASTM A 653/A 653M galvanized-steel profiles, 0.06 inch thick.
   
   2) Hat-shaped channel with integral flanges. Mating face shall be a minimum of 1 inch.
   
   3) Width not less than 5 inches.

b. Blades:

   1) Hollow, airfoil, galvanized steel.
   
   2) Parallel or opposed blade configuration as required by application.
   
   3) Material: ASTM A 653/A 653M galvanized steel, 0.05 inch thick.
   
   4) Width not to exceed 6 inches.
   
   5) Length as required by close-off pressure, not to exceed 48 inches.

c. Seals:

   1) Blades: Replaceable, mechanically attached extruded silicone, vinyl, or plastic composite.
   
   2) Jams: Stainless steel, compression type.

d. Axles: 0.5-inch- diameter stainless steel, mechanically attached to blades.

e. Bearings:

   1) Stainless steel mounted in frame.
   
   2) Where blade axles are installed in vertical position, provide thrust bearings.
f. Linkage:

1) Concealed in frame.
2) Constructed of aluminum and stainless steel.
3) Hardware: Stainless steel.

g. Transition:

1) For round and flat oval duct applications, provide damper assembly with integral transitions to mate to adjoining field connection.
2) Factory mount damper in a sleeve with a close transition to mate to field connection.
3) Damper size and sleeve shall be connection size plus 2 inches.
4) Sleeve length shall be not less than 12 inches for dampers without jackshafts and shall be not less than 16 inches for dampers with jackshafts.
5) Sleeve material shall match adjacent duct.

h. Additional Corrosion Protection for Corrosive Environments:

1) Provide epoxy finish for surfaces in contact with airstream.
2) Axles, damper linkage, and hardware shall be constructed of Type 316L stainless steel.

D. Rectangular Dampers with Aluminum Flat Blades:

1. Performance:
   a. Leakage: Leakage shall not exceed 3.2 cfm/sq. ft. against 1-in. wg differential static pressure.
   b. Pressure Drop: 0.07-in. wg at 1500 fpm across a 24-by-24-inch damper when tested according to AMCA 500-D, figure 5.3.
   c. Velocity: Up to 2000 fpm.
   d. Temperature: Minus 50 to plus 250 deg F.
   e. Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length, not to exceed 3-in. wg.
   f. Damper shall have AMCA seal for both air leakage and air performance.

2. Construction:
   a. Frame:
      1) Material: ASTM B 211, Alloy 6063 T5 extruded-aluminum profiles, 0.12 inch thick.
      2) Hat-shaped channel.
      3) Width not less than 5 inches.
   b. Blades:
      1) Flat blades of extruded aluminum.
      2) Parallel or opposed blade configuration as required by application.
      3) Material: ASTM B 211, Alloy 6063 T5 extruded-aluminum profiles, 0.12 inch thick.
      4) Width not to exceed 6 inches.
      5) Length as required by close-off pressure, not to exceed 48 inches.
   c. Seals:
1) Blades: Replaceable, mechanically attached extruded silicone, vinyl or plastic composite.
2) Jambs: Stainless steel, compression type.

d. Axles: 0.5-inch-diameter stainless steel, mechanically attached to blades.
e. Bearings:
   1) Molded-synthetic sleeve, mounted in frame.
   2) Where blade axles are installed in vertical position, provide thrust bearings.

f. Linkage:
   1) Concealed in frame.
   2) Constructed of stainless steel.
   3) Hardware: Stainless steel.

g. Transition:
   1) For round and flat oval duct applications, provide damper assembly with integral transitions to mate to adjoining field connection.
   2) Factory mount damper in a sleeve with a close transition to mate to field connection.
   3) Damper size and sleeve shall be connection size plus 2 inches.
   4) Sleeve length shall be not less than 12 inches for dampers without jackshafts and shall be not less than 16 inches for dampers with jackshafts.
   5) Sleeve material shall match adjacent duct.

h. Additional Corrosion Protection for Corrosive Environments:
   1) Provide anodized finish for aluminum surfaces in contact with airstream. Anodized finish shall be a minimum of 0.0007 inch thick.
   2) Axles, damper linkage, and hardware shall be constructed of Type 316L stainless steel.

E. Rectangular Dampers with Steel Flat Blades:

1. Performance:
   a. Leakage: Leakage shall not exceed 4.8 cfm/sq. ft. against 1-in. wg differential static pressure.
   b. Pressure Drop: 0.1-in. wg at 1500 fpm across a 24-by-24-inch damper when tested according to AMCA 500-D, figure 5.3.
   c. Velocity: Up to 1500 fpm.
   d. Temperature: Minus 25 to plus 180 deg F.
   e. Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length, not to exceed 4-in. wg.
   f. Damper shall have AMCA seal for both air leakage and air performance.

2. Construction:
   a. Frame:
      1) Material: Galvanized or stainless steel, 0.06 inch thick.
      2) Hat-shaped channel.
      3) Width not less than 5 inches.
b. Blades:
   1) Flat blades with multiple grooves positioned axially for reinforcement.
   2) Parallel or opposed blade configuration as required by application.
   3) Material: Galvanized or stainless steel, 0.06 inch thick.
   4) Width not to exceed 6 inches.
   5) Length as required by close-off pressure, not to exceed 48 inches.

c. Seals:
   1) Blades: Replaceable, mechanically attached, PVC-coated polyester.
   2) Jambs: Stainless steel, compression type.

d. Axles: 0.5-inch-diameter stainless steel, mechanically attached to blades.

e. Bearings:
   1) Molded-synthetic sleeve, mounted in frame.
   2) Where blade axles are installed in vertical position, provide thrust bearings.

f. Linkage:
   1) Concealed in frame.
   2) Constructed of stainless steel.
   3) Hardware: Stainless steel.

2.3 GENERAL CONTROL-DAMPER ACTUATORS REQUIREMENTS

A. Actuators shall operate related damper(s) with sufficient reserve power to provide smooth modulating action or two-position action and proper speed of response at velocity and pressure conditions to which the damper is subjected.

B. Actuators shall produce sufficient power and torque to close off against the maximum system pressures encountered. Actuators shall be sized to close off against the fan shutoff pressure as a minimum requirement.

C. The total damper area operated by an actuator shall not exceed 80 percent of manufacturer's maximum area rating.

D. Provide one actuator for each damper assembly where possible. Multiple actuators required to drive a single damper assembly shall operate in unison.

E. Avoid the use of excessively oversized actuators which could overdrive and cause linkage failure when the damper blade has reached either its full open or closed position.

F. Use jackshafts and shaft couplings in lieu of blade-to-blade linkages when driving axially aligned damper sections.

G. Provide mounting hardware and linkages for connecting actuator to damper.

H. Select actuators to fail in desired position in the event of a power failure.
2.4 ELECTRIC AND ELECTRONIC ACTUATORS

A. Type: Motor operated, with or without gears, electric and electronic.

B. Voltage:
   1. Voltage selection is delegated to professional designing control system [24 V] [120 V] <Insert requirement>.
   2. Actuator shall deliver torque required for continuous uniform movement of controlled device from limit to limit when operated at rated voltage.
   3. Actuator shall function properly within a range of 85 to 120 percent of nameplate voltage.

C. Construction:
   1. Less Than 100 W: Fiber or reinforced nylon gears with steel shaft, copper alloy or nylon bearings, and pressed steel enclosures.
   2. 100 up to 400 W: Gears ground steel, oil immersed, shaft-hardened steel running in bronze, copper alloy, or ball bearings. Operator and gear trains shall be totally enclosed in dustproof cast-iron, cast-steel, or cast-aluminum housing.

D. Field Adjustment:
   1. Spring return actuators shall be easily switchable from fail open to fail closed in the field without replacement.
   2. Provide gear-type actuators with an external manual adjustment mechanism to allow manual positioning of the damper when the actuator is not powered.

E. Two-Position Actuators: Single direction, spring return or reversing type.

F. Modulating Actuators:
   1. Capable of stopping at all points across full range, and starting in either direction from any point in range.
   2. Control Input Signal:
      a. Three Point, Tristate, or Floating Point: Clockwise and counter-clockwise inputs. One input drives actuator to open position, and other input drives actuator to close position. No signal of either input remains in last position.
      b. Proportional: Actuator drives proportional to input signal and modulates throughout its angle of rotation. Suitable for zero- to 10- or 2- to 10-V dc and 4- to 20-mA signals.

G. Position Feedback:
   1. Equip two-position actuators with limits switches or other positive means of a position indication signal for remote monitoring of [open] [and] [close] position.
   2. Equip modulating actuators with a position feedback through current or voltage signal for remote monitoring.
   3. Provide a position indicator and graduated scale on each actuator indicating open and closed travel limits.

H. Fail-Safe:
CONTROL DAMPERS

1. Where indicated, provide actuator to fail to an end position.
2. Internal spring return mechanism to drive controlled device to an end position (open or close) on loss of power.
3. Batteries, capacitors, and other non-mechanical forms of fail-safe operation are acceptable only where uniquely indicated.

I. Integral Overload Protection:
1. Provide against overload throughout the entire operating range in both directions.
2. Electronic overload, digital rotation sensing circuitry, mechanical end switches, or magnetic clutches are acceptable methods of protection.

J. Damper Attachment:
1. Unless otherwise required for damper interface, provide actuator designed to be directly coupled to damper shaft without need for connecting linkages.
2. Attach actuator to damper drive shaft in a way that ensures maximum transfer of power and torque without slippage.
3. Bolt and set screw method of attachment is acceptable only if provided with at least two points of attachment.

K. Temperature and Humidity:
1. Temperature: Suitable for operating temperature range encountered by application with minimum operating temperature range of minus 20 to plus 120 deg F.
2. Humidity: Suitable for humidity range encountered by application; minimum operating range shall be from 5 to 95 percent relative humidity, non-condensing.

L. Enclosure:
1. Suitable for ambient conditions encountered by application.
2. NEMA 250, Type 2 for indoor and protected applications.
3. NEMA 250, Type 4 or Type 4X for outdoor and unprotected applications.
4. Provide actuator enclosure with a heater and controller where required by application.

M. Stroke Time:
1. Operate damper from fully closed to fully open within 60 seconds.
2. Operate damper from fully open to fully closed within 60 seconds.
3. Move damper to failed position within 30 seconds.
4. Select operating speed to be compatible with equipment and system operation.
5. Actuators operating in smoke control systems comply with governing code and NFPA requirements.

N. Sound:
1. Spring Return: 62 dBA.
2. Non-Spring Return: 45 dBA.
PART 3 - EXECUTION

3.1 CONTROL-DAMPER APPLICATIONS

A. Control Dampers:

B. Select from damper types indicated in "Control Dampers" Article to achieve performance requirements and characteristics indicated while subjected to full range of system operation encountered.

1. Rectangular Exhaust Air Duct Applications with SMACNA Construction Class and Velocities to:
   Rectangular dampers with aluminum airfoil blades.
2. Round Exhaust Air Duct Applications with SMACNA Construction Class and Velocities to:
   Rectangular dampers with aluminum airfoil blades.
3. Rectangular Outdoor Air Duct Applications with SMACNA Construction Class and Velocities to:
   Rectangular dampers with aluminum airfoil blades.
4. Round Outdoor Air Duct Applications with SMACNA Construction Class and Velocities to:
   Rectangular dampers with aluminum airfoil blades.
5. Rectangular Return Air Duct Applications with SMACNA Construction Class and Velocities to:
   Rectangular dampers with aluminum airfoil blades.
6. Round Return Air Duct Applications with SMACNA Construction Class and Velocities to:
   Rectangular dampers with aluminum airfoil blades.
7. Rectangular Supply Air Duct Applications with SMACNA Construction Class and Velocities to:
   Rectangular dampers with aluminum airfoil blades.
8. Round Supply Air Duct Applications with SMACNA Construction Class and Velocities to:
   Rectangular dampers with aluminum airfoil blades.

3.2 INSTALLATION, GENERAL

A. Furnish and install products required to satisfy most stringent requirements indicated.

B. Properly support dampers and actuators, tubing, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to a seismic force.

C. Provide ceiling, floor, roof, and wall openings and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

D. Seal penetrations made in fire-rated and acoustically rated assemblies.

E. Fastening Hardware:

1. Stillson wrenches, pliers, or other tools that will cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

F. Install products in locations that are accessible and that will permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.
G. Corrosive Environments:

1. Use products that are suitable for environment to which they will be subjected.
2. If possible, avoid or limit use of materials in corrosive environments, including, but not limited to, the following:
   a. Laboratory exhaust airstreams.
3. Use Type 316 stainless-steel tubing and fittings when in contact with a corrosive environment.
4. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
5. Where actuators are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.3 ELECTRIC POWER

A. Furnish and install electrical power to products requiring electrical connections.
B. Furnish and install circuit breakers. Comply with requirements in Section 26 28 16 "Enclosed Switches and Circuit Breakers."
C. Furnish and install power wiring. Comply with requirements in Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."
D. Furnish and install raceways. Comply with requirements in Section 26 05 33 "Raceways and Boxes for Electrical Systems."

3.4 CONTROL DAMPERS

A. Install smooth transitions, not exceeding 15 degrees, to dampers smaller than adjacent duct. Install transitions as close to damper as possible but at distance to avoid interference and impact to performance. Consult manufacturer for recommended clearance.

B. Clearance:
   1. Locate dampers for easy access and provide separate support of dampers that cannot be handled by service personnel without hoisting mechanism.
   2. Install dampers with at least 24 inches of clear space on sides of dampers requiring service access.

C. Service Access:
   1. Dampers and actuators shall be accessible for visual inspection and service.
   2. Install access door(s) in duct or equipment located upstream of damper to allow service personnel to hand clean any portion of damper, linkage, and actuator. Comply with requirements in Section 23 33 00 "Air Duct Accessories."

D. Install dampers straight and true, level in all planes, and square in all dimensions. Install supplementary structural steel reinforcement for large multiple-section dampers if factory support alone cannot handle loading.
E. Attach actuator(s) to damper drive shaft.

F. For duct-mounted and equipment-mounted dampers installed outside of equipment, install a visible and accessible indication of damper position from outside.

G. Connect electrical devices and components to electrical grounding system. Comply with requirements in Section 26 05 26 "Grounding and Bonding for Electrical Systems."

H. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems." Section 16075 "Electrical Identification."

I. Install engraved phenolic nameplate with damper identification on damper.

3.5 CHECKOUT PROCEDURES

A. Control-Damper Checkout:

1. Check installed products before continuity tests, leak tests, and calibration.
2. Check dampers for proper location and accessibility.
3. Verify that control dampers are installed correctly for flow direction.
4. Verify that proper blade alignment, either parallel or opposed, has been provided.
5. Verify that damper frame attachment is properly secured and sealed.
6. Verify that damper actuator and linkage attachment are secure.
7. Verify that actuator wiring is complete, enclosed, and connected to correct power source.
8. Verify that damper blade travel is unobstructed.

3.6 ADJUSTMENT, CALIBRATION, AND TESTING:

A. Stroke and adjust control dampers following manufacturer's recommended procedure, from 100 percent open to 100 percent closed back to 100 percent open.

B. Check and document open and close cycle times for applications with a cycle time of less than 30 seconds.

C. For control dampers equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

END OF SECTION 23 09 23.12
SECTION 23 09 23.13 - ENERGY METERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes thermal and electric power energy meters that connect to DDC systems.

B. Related Requirements:
   1. Section 23 09 23 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.
   2. Section 23 09 93 "Sequence of Operations for HVAC Controls" for requirements that relate to Section 23 09 23.13.

C. Integration: Energy meters must interface to “Square D” ION metering systems that are used by MSU.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. LEED Submittals: Product data for energy instruments for use in showing compliance with measurement and verification credit.

C. Shop Drawings:
   1. Include plans, elevations, sections, and mounting details.
   2. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each product requiring a certificate.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 THERMAL ENERGY METERS

A. Performance Requirements: Manufacturer shall certify that each energy meter indicated complies with specified performance requirements and characteristics.
   1. Product certificates are required.
B. Insertion-Type Thermal Energy Meters:

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

2. Description:
   a. Factory-packaged meter consisting of supply and return temperature sensors, flow sensor, digital display, keypad user interface, installation hardware, color-coded interconnecting cabling, and installation instructions.
   b. Each thermal energy meter shall be individually calibrated and provided with calibration certification traceable to NIST.

3. Alphanumeric display of the following on face of enclosure:
   a. Total energy consumption.
   b. Energy rate.
   c. Flow rate.
   d. Supply temperature.
   e. Return temperature.
   f. Visual indication of power status (on/off) on face of enclosure.

4. Electronics Enclosure:
   a. Remote from temperature and flow sensors.
   b. NEMA 250, Type 12 or Type 13 for indoor applications and NEMA 250, Type 4 or Type 4X for outdoor applications.
   c. Labeled terminal strip for field wiring connections.

5. Programming:
   a. Factory programmed for specific application and field programmable through keypad on face of enclosure.
   b. Programmed parameters and total energy consumption shall be stored in non-volatile EEPROM memory.

6. Output Signals:
   a. Total Energy Consumption: Isolated solid-state dry contact with 100 mA, 50-V rating and contact duration of 0.5, 1, 2, or 6 seconds.
   b. Energy Rate, Flow Rate, Supply Temperature, Return Temperature: 4 to 20 mA or zero- to 10-V dc for each.
   c. In lieu of hardwired analog signals, a serial communication interface may be used.

7. Serial Communication Interface: Compatible with host to share total energy consumption, energy rate, flow rate, and supply and return temperature data.

8. Temperature Sensors:
   a. Temperature range matched to application.
   b. Differential temperature accuracy within 0.15 deg F over the calibrated range.
   c. NEMA 250, Type 4 junction box with thermal isolation.
   d. Stainless-steel thermowell with NPS 1/2 NPT connection for each sensor.
9. **Flow Sensors/Meters:**
   
   a. Suitable for an operating pressure of at least 200 psig.
   
   b. Meters shall be suitable for maximum system temperatures encountered, but not less than 250 deg F.
   
   c. Pressure drop not to exceed 1 psig at 20-fps flow velocity in NPS 2 pipe and decreasing in large pipe with lower velocity.
   
   d. Sensor Accuracy:
      
      1) Within 1 percent of actual flow between the flow velocity range of 0.4 to 20 fps.
      
   e. Wet calibrate and tag each sensor to standards traceable to NIST, and provide each sensor with a certificate of calibration.
   
   f. Water, Water/Glycol, Steam Condensate: Provide magnetic flow meter with full bore body with encapsulated and rigidly retained set of coils. Provide with local readout and dry-contact pulsing output. Reading to be in multiple of pounds. Interface to be compatible with Square D Ion Metering System installed at MSU for consumption monitoring.
   
   g. House the sensor electronics in a NEMA 250, Type 4 weathertight aluminum enclosure with a gasketed cover. Housing shall include connection for field-installed conduit.
   
   h. Sensor cable length shall be sufficient to connect to display module.
   
   i. Sensor housing shall have full-port Type 316 stainless-steel ball valve for system isolation.

10. **Power Supply:**
   
   a. Field Power: 120-V ac, 60 Hz unless otherwise required by the application.
   
   b. Internal Power: As required by flow meter.

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**PART 3 - EXECUTION**

### 3.1 INSTALLATION, GENERAL

A. Install products level, plumb, parallel, and perpendicular with building construction.

B. Support instruments, tubing, piping wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to a seismic force.

C. Install products in locations that are accessible and that will permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

### 3.2 ELECTRIC POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 26 28 16 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."
D. Furnish and install raceways. Comply with requirements in Section 26 05 33 "Raceways and Boxes for Electrical Systems."

3.3 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain instrumentation and control devices.

B. Coordinate video with operation and maintenance manuals and classroom instruction for use by Owner in operating, maintaining, and troubleshooting.

C. Record videos on DVD disks.

D. Owner shall have right to make additional copies of video for internal use without paying royalties.

END OF SECTION 23 09 23.13
SECTION 23 09 23.14 - FLOW INSTRUMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Airflow sensors.
2. Airflow switches.
3. Airflow transmitters.
4. Liquid flow meters.
5. Liquid flow sensors.
6. Steam Flow Sensors
7. Liquid flow switches.
8. Liquid flow transmitters.

B. Related Requirements:

1. Section 23 09 23 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.
2. Section 23 09 93 "Sequence of Operations for HVAC Controls" for requirements that relate to Section 23 09 23.14.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.


C. Shop Drawings:

1. Include plans, elevations, sections, and mounting details.
2. Include diagrams for power, signal, and control wiring.
3. Include diagrams for air and process signal tubing.
4. Number-coded identification system for unique identification of wiring, cable, and tubing ends.

D. Delegated-Design Submittal:

1. Schedule and design calculations for flow instruments, including the following.
   a. Flow at Project design and minimum flow conditions.
   b. Pressure drop at Project design and minimum flow conditions.

1.3 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each product requiring a certificate.
1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Select and size products to achieve specified performance requirements.

B. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 GENERAL REQUIREMENTS FOR FLOW INSTRUMENTS

A. Air sensors and transmitters shall have an extended range of 20 percent above Project design flow and 20 percent below minimum Project flow to signal abnormal flow conditions and to provide flexibility for changes in operation.

B. Liquid and steam sensors, meters, and transmitters shall have an extended range of 20 percent above Project design flow and 20 percent below Project minimum flow to signal abnormal flow conditions and to provide flexibility for changes in operation.

2.3 AIRFLOW SENSORS:

A. Performance Requirements:

1. Adjustable for changes in system operational parameters.
2. Airflow Sensor and Transmitter Range: Extended range of 20 percent above Project design flow and 20 percent below minimum Project flow to signal abnormal flow conditions.
3. Manufacturer shall certify that each flow instrument indicated complies with specified performance requirements and characteristics.
   a. Product certificates are required.

B. Pitot-Tube Airflow Sensor Station:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Air Monitor Corporation
2. Description: Multiple total- and static-pressure sensors positioned at the center of equal area of the station cross section and interconnected by respective averaging manifolds.
   a. Stations 4 sq. ft. and Smaller: One total-pressure sensor and one static-pressure sensor for every 16 sq. in. of station area.
   b. Stations Larger than 4 sq. ft.: One total-pressure sensor and one static-pressure sensor for every 36 sq. in. of station area.
3. Casing: Galvanized sheet steel at least 0.079 inch thick with coating complying with ASTM A 653/A 653M, G90. Casings shall be stainless steel, 0.0781 inch thick, when connected to stainless duct and aluminum, 0.063 inch thick, when connected to aluminum duct.
   a. Joints and Seams: Continuously weld. Clean galvanized areas damaged by welding and coat with aluminum paint.
   b. Casing Depth: At least 8 inches.
   c. Casing Flanges: Outward flange, minimum flange face 1.5 inches.
   d. Casing Configuration and Size: Match shape (rectangular, round, flat oval) and same size as adjacent duct unless otherwise indicated.

4. Include an open parallel cell air straightener or air equalizer honeycomb mechanically fastened to casing.
   a. Construct straightener or equalizer from Type 3003 aluminum or Type 316 stainless steel, depending on casing material. Use stainless steel for units with stainless-steel casings.

5. Construct pressure sensor array from drawn copper or stainless-steel tubing. Use stainless steel for units with stainless-steel casings. Copper tubing shall comply with ASTM B 75 and ASTM B 280. Minimum tube wall thickness shall be 0.030 inch. Include internal piping and external pressure transmitter ports.

6. Station Labeling: Identification label on each station casing indicating model number, size, area, and application-specific airflow range.

7. Performance:
   a. Pressure Loss: 0.015-inch wg at 1000 fpm, or 0.085-inch wg at 2000 fpm.
   b. Accuracy: Within 2 percent of actual airflow.
   c. Self-Generated Sound: NC 40 and sound level within the duct shall not be amplified.
   d. Performance rated and tested according to AMCA 610. Each station shall bear the AMCA seal.

C. Thermal Airflow Station:

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

2. Source Limitations: Obtain airflow and temperature measuring sensors and transmitters from single manufacturer.

3. Description: Airflow station shall consist of one or more sensor probes and a remotely mounted microprocessor-based transmitter.

4. Performance:
   a. Capable of independently processing up to 16 independently wired sensor assemblies.
   b. Airflow rate of each sensor assembly shall be equally weighted and averaged by transmitter prior to output.
   c. Temperature of each sensor assembly shall be velocity weighted and averaged by transmitter prior to output.
   d. Listed and labeled by an NRTL as successfully tested as an assembly according to UL 873, "Temperature-Indicating and Regulating Equipment."
   e. Components shall be interconnected by exposed NRTL-listed plenum-rated cable or non-listed cable placed in conduit.
   f. Each flow station shall be factory calibrated at a minimum of 16 airflow rates and three temperatures to standards that are traceable to NIST.
g. **Airflow Accuracy:** Within 2 percent of reading over the entire operating airflow range.

1) Devices whose accuracy is combined accuracy of transmitter and sensor probes must demonstrate that total accuracy meets the performance requirements throughout the measurement range.

h. **Temperature Accuracy:** Within 0.2 deg F over entire operating range of minus 20 to plus 140 deg F.

i. **Sensor Ambient Operating Temperature Range:** Minus 20 to plus 160 deg F.

j. **Transmitter Ambient Operating Temperature Range:** Minus 20 to plus 120 deg F.

k. **Sensor and Transmitter Ambient Operating Humidity Range:** Zero to 99 percent, non-condensing.

l. Instrument shall compensate for changes in air temperature and density throughout calibrated velocity range for seasonal extremes at Project location.

m. **Pressure Drop:** 0.05-inch wg at 2000 fpm across a 24-by-24-inch area.

n. Instruments mounted in throat or face of fan inlet cone shall not negatively influence fan performance by reducing flow more than 2 percent of Project design flow or negatively impact fan-generated sound. Losses in performance shall be documented with submittal data, and adjustments to compensate for performance impact shall be made to fan in order to deliver Project design airflow indicated.

5. **Sensor Assemblies:**

a. Each sensor probe shall contain two individually wired, hermetically sealed bead-in-glass thermistors.

b. Mount thermistors in sensor using a marine-grade, waterproof epoxy.

c. Thermistor leads shall be protected and not exposed to the environment.

d. Each sensor assembly shall independently determine airflow rate and temperature at each measurement point.

e. Each sensor probe shall have an integral cable for connection to remotely mounted transmitter.

f. **Sensor Probe Material:** Gold anodized, extruded 6063 aluminum tube or Type 304 stainless steel.

6. **Casing:**

a. Factory mount sensor probes in an airflow station casing to create a single assembly for field mounting.

b. **Material:** Galvanized sheet steel at least 0.079 inch thick with coating complying with ASTM A 653/A 653M, G90. Casings shall be stainless steel, 0.0781 inch thick, when connected to stainless duct and aluminum, 0.063 inch thick, when connected to aluminum duct.

c. **Joints and Seams:** Continuously weld. Clean galvanized areas damaged by welding and coat with zinc-rich paint.

d. **Casing Depth:** At least 8 inches.

e. Include casing inlet and discharge connections with a minimum 1.5-inch face flange.

7. **Transmitter:**

a. Integral digital display capable of simultaneously displaying total airflow and average temperature, individual airflow, and temperature readings of each independent sensor assembly.

b. Capable of field configuration and diagnostics using an onboard push-button interface and digital display.
1) Include an integral power switch to operate on 24-V ac (isolation not required) and include the following:

   a) Integral protection from transients and power surges.
   b) Circuitry to ensure reset after power disruption, transients, and brownouts.
   c) Integral transformer to convert field power source to operating voltage required by instrument.

c. Remote Signal Interface:

   1) Linear Analog Signals for Airflow and Temperature: Fuse protected and isolated, field selectable, zero- to 10-V dc or 4 to 20 mA.

2.4 AIRFLOW SWITCHES

A. Polymer Film Sail Switch:

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

      a. Honeywell International

   2. Performance:

      a. Suitable for applications operating at velocities up to 400 fpm.
      b. Suitable for mounting with air direction in horizontal, vertical up or down.
      c. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
      d. Voltage: 24-, 120-, 240-V ac.
      e. Normally Open Full Load Current: 2 A at 120-V ac.
      f. Normally Closed Full Load Current: 1 A at 120-V ac.
      g. Normally open switch actuates at 250 fpm and opens at 75 fpm.
      h. Normally closed switch actuates at 75 fpm and closes at 250 fpm.
      i. Maximum Process Temperature: 170 deg F.
      j. Maximum Ambient Temperature: 125 deg F.

   3. Construction:

      a. Polyester film sail encasing a wire frame.
      b. Sail actuates a SPDT snap switch.
      d. Enclosure with removable cover.
      e. NEMA 250, Type 1 enclosure.
      f. Removable spring counterbalances sail to allow mounting in either vertical (up or down) or horizontal airflow.
      g. Electrical Connections: Screw terminals.
      h. Conduit Connections: 1/2-inch trade size conduit knock outs on top and bottom.

B. Stainless-Steel Single Vane Switch:

   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
2. Description:
   a. Velocities up to 2000 fpm.
   b. Suitable for mounting with air direction in horizontal.

3. Performance:
   a. Voltage: 125-, 240-, and 480-V ac.
   b. Full Load Current: 9.8 A at 125-V ac.
   c. Field-Adjustable Velocity Set Point: 400 to 1600 fpm.
   d. Maximum Process Temperature: 180 deg F.
   e. Maximum Ambient Temperature: 125 deg F.

4. Construction:
   a. Stainless-steel vane.
   b. Vane actuates a SPDT snap switch.
   d. Enclosure with removable cover.
   e. NEMA 250, Type 1 enclosure.
   f. Screw set-point adjustment.
   g. Electrical Connections: Screw terminals.
   h. Conduit Connections: 1-inch trade size conduit knock outs on top and bottom.

2.5 AIRFLOW TRANSMITTERS

A. Airflow Transmitters with 0.25 Percent Accuracy and Auto-Zero Feature:

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

2. Transmitter shall receive total- and static-pressure signals from a flow element, amplify signals, extract the square foot, and scale the signals to produce 4- to 20-mA dc output signals linear to airflow.

3. NEMA 250, Type 1 enclosure.

4. Construct assembly so shock, vibration, and pressures surges of up to 1 psig will neither harm transmitter, nor affect its accuracy.

5. Transmitter with automatic zeroing circuit capable of automatically readjusting transmitter zero at predetermined time intervals. The automatic zeroing circuit shall re-zero the transmitter to within 0.1 percent of true zero.

6. Performance:
   a. Range: As required by application and at least 10 percent below minimum airflow and 10 percent greater than design airflow.
   b. Calibrated Span: Field adjustable, minus 40 percent of the range.
   c. Accuracy: Within 0.25 percent of natural span.
   d. Repeatability: Within 0.15 percent of calibrated span.
   e. Linearity: Within 0.2 percent of calibrated span.
   f. Hysteresis and Deadband (Combined): Less than 0.2 percent of calibrated span.
7. Integral digital display for continuous indication of airflow.

B. Pressure Differential Transmitters for Airflow Measurement:

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

2. Performance:
   a. Range: As required by application and at least 10 percent below minimum airflow and 10 percent greater than design airflow.
   b. Accuracy: Within 0.5 percent of the full-scale range.
   c. Hysteresis: Within 0.10 percent of full scale.
   d. Repeatability: Within 0.05 percent of full scale.
   e. Stability: Within one percent of span per year.
   f. Overpressure: 10 psig.
   g. Temperature Limits: Zero to 150 deg F.
   h. Compensate Temperature Limits: 40 to 150 deg F.
   i. Thermal Effects: 0.033 percent of full scale per degree F.
   j. Shock and vibration shall not harm the transmitter.

3. Output Signals:
   a. Analog Current Signal:
      1) Two-wire, 4- to 20-mA dc current source.
      2) Signal capable of operating into 800-ohm load.
   b. Analog Voltage Signal:
      1) Three wire, zero to 10 V.
      2) Minimum Load Resistance: 1000 ohms.

4. Display: Four-digit digital with minimum 0.4-inch-high numeric characters.

5. Operator Interface:
   a. Zero and span adjustments located behind cover.

6. Construction:
   a. Plastic casing with removable plastic cover.
   b. Fittings: Swivel fittings for connection to copper tubing or barbed fittings for connection to polyethylene tubing. Fittings on bottom of instrument case.
   c. Screw terminal block for wire connections.
   d. Vertical plane mounting.
   e. NEMA 250, Type 4.
   f. Mounting Bracket: Appropriate for installation.

2.6 LIQUID FLOW METERS

A. General Requirements for Liquid Flow Meters:
1. Adjustable for changes in system operational parameters.
2. Liquid and Steam Sensors, Meters, and Transmitters: Extended range of 20 percent above Project design flow and 20 percent below Project minimum flow to signal abnormal flow conditions.
3. Manufacturer shall certify that each flow instrument indicated complies with specified performance requirements and characteristics.
4. Product certificates are required.

B. Insertion Paddle Wheel Flow Meter, NPS 1:

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

2. Description:
   a. Insertion-type meter with a non-magnetic spinning paddle wheel.
   b. Each meter shall be wet calibrated at factory to standards traceable to NIST and provided with a certificate of calibration.
   c. Programming kit including cable connector and Microsoft-Windows-compatible software.
   d. Where indicated, provide meter with bi-directional flow measurement.

3. Performance:
   a. Range: 0.33 to 20 fps.
   b. Accuracy: Within 0.5 percent of flow rate.
   c. Repeatability: Within 0.5 percent.
   d. Ambient Temperature: 14 to 150 deg F.
   e. Maximum Process Temperature: 300 deg F with PEEK sensor tip.
   f. Maximum Pressure: 350 psig at 300 deg F with PEEK sensor tip.
   g. Pressure Drop: Up to 0.5 psig at 10 fps for pipe sizes NPS 1-1/2 and larger.

4. Output Signal:
   a. Unidirectional Flow Meter: Analog, two wire, loop-powered, 4- to 20-mA signal.
   b. Bi-directional Flow Meter: Analog 4- to 20-mA signal plus direction.

5. Operator Interface:
   a. Programming: Instrument programming through computer and programming kit.
   b. Digital Display: Eight-character digital display of flow rate, flow totalization, input, output, and flow direction for bi-directional meters.

6. Construction:
   a. Wetted Metal Parts (Including Sensor Stem, Mounting Adapter, and Isolation Valve): Type 316 stainless steel.
   b. Sensor Tip: PPS or PEEK.
   c. Shaft: Tungsten carbide.
   d. Impeller: Stainless steel.
   f. Instrument Isolation Valve: Full port ball valve for system isolation.
   g. Insertion Depth: Threaded positioning nut for accurate sensor depth in the pipe.
h. Electronics Enclosure:
   1) Polypropylene with Viton-sealed acrylic cover.
   2) Removable cover.
   3) NEMA 250, Type 4X.
   4) Electrical Connection: Screw terminals.
   5) Conduit Connection: 1/2-inch trade size.

C. Insertion Turbine Flow Meter:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. ONICON Inc.
   b. Spirax Sarco, Inc.

2. Description:
   a. Operating pressure of 300 psig with a temperature of 200 deg F.
   b. Meters in hot water systems shall be suitable for maximum system temperatures encountered, but not less than 250 deg F.
   c. Pressure drop not to exceed 1 psig at 20-fps flow velocity in a NPS 2 pipe and decreasing in large pipe with lower velocity.
   d. Sensor Accuracy:
      1) Within 1 percent of actual flow between the flow velocity range of 3 to 30 fps.
      2) Within 2 percent of actual flow between the flow velocity range of 0.4 to 20 fps.
      3) Within 0.5 percent of actual reading at the calibrated velocity.
   e. Wet calibrate and tag sensors to standards traceable to NIST, and provide each sensor with a certificate of calibration.

3. Sensor:
   a. For Pipe Sizes NPS 2 and Smaller: Single turbine sensors.
   b. For Pipe Sizes NPS 2-1/2 and Larger: Dual turbine sensors.
   c. Piping with Bi-directional Flow: Bi-directional dual turbine sensors.
   d. Dual turbine sensors shall have dual, contra-rotating turbine elements, each turbine element with its own rotational sensing system, and an averaging circuit.
   e. Rotational sensing of each turbine shall be accomplished electronically by sensing electronic impedance change (non-magnetic and non-photoelectric).
   f. Sensor shall have an integral frequency output linear with flow rate. For dual turbine units, with individual top and bottom turbine outputs for diagnostic purposes.
   g. Bi-directional sensors shall have isolated solid-state dry contacts with a contact rating of 100 mA at 50 V. The contacts shall close when the flow in direction of arrow is 0.18 fps or more.
   h. Flow sensor shall be complete with installation hardware necessary to enable insertion and removal from pipe without system shutdown.
   i. Construct turbine elements of polypropylene with sapphire jewel bearings and tungsten carbide shafts. Construct wetted metal components of Type 316 stainless steel, including installation hardware.
   j. House sensor electronics in a NEMA 250, Type 4 enclosure.
   k. Enclosure shall include connection(s) for field-installed conduit.
   l. Sensor shall have cable of length sufficient to connect to display module.
   m. Sensor housing shall have full port Type 316 stainless-steel ball valve for system isolation.
4. **Display Module:**
   
a. Remote from sensor.
b. House in a NEMA 250, Type 4X enclosure.
c. Label terminal strip for all wiring connections.
d. 120-V ac power supply with 24-V dc output to power the flow sensor.
e. **Remote Interface:**
   
   1) Hardwired Analog Outputs for Flow Rate and Totalization: 4 to 20 mA and zero- to 10-V dc.
   2) Serial Communication Interface: Compatible with host to share flow rate and totalized flow data.
   3) Outputs linear to within 0.1 percent of calibrated span.
   
f. Digital display for flow rate and totalized flow.
   
   1) At least eight display digits for totalization.
   2) Bi-directional units with separate digital display for flow and totalization in each direction.

   g. Local reset of flow totalization.
   
h. Program and data shall be stored in nonvolatile memory in event of power loss.
i. For bi-directional units, with display of flow direction (contacts open or closed).

D. **Inline Turbine Flow Meter:**

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

2. **Description:**
   
b. Operating pressure of 300 psig with a temperature of 200 deg F.
c. Meters in hot water systems shall be suitable for maximum system temperatures encountered, but not less than 250 deg F.
d. Pressure drop not to exceed 3 psig at 38 gpm.
e. **Sensor Accuracy:**
   
   1) Within 2 percent of actual flow between the flow range of 0.8 to 38 gpm.
   2) Within 0.5 percent of actual reading at the calibrated velocity.

   f. Wet calibrate and tag sensors to standards traceable to NIST, and provide each sensor with a certificate of calibration.

3. **Sensor:**
   
a. Rotational sensing of turbine shall be accomplished electronically by sensing electronic impedance change (non-magnetic and non-photoelectric).
b. Sensor shall have an integral frequency output linear with flow rate.
c. Sensor shall have threaded union on each end.
d. Construct turbine elements of polypropylene with sapphire jewel bearings and tungsten carbide shafts.
e. Construct wetted metal components of brass or stainless steel.
f. House sensor electronics in a NEMA 250, Type 4 enclosure.
g. Enclosure shall include connection(s) for field-installed conduit.
h. Sensor shall have cable of length sufficient to connect to display module.

4. Display Module:
   a. Remote from sensor.
   b. Enclosure: NEMA 250, Type 4X.
   c. Label terminal strip for all wiring connections.
   d. 120-V ac power supply with 24-V dc output to power the flow sensor.
   e. Remote Interface:
      1) Hardwired Analog Outputs for Flow Rate and Totalization: 4 to 20 mA and zero-to-10-V dc.
      2) Serial Communication Interface: Compatible with host to share flow rate and totalized flow data.
      3) Outputs linear to within 0.1 percent of calibrated span.
   f. Digital display of flow rate and totalized flow.
   g. At least eight display digits for totalization.
   h. Local reset of flow totalization.
   i. Program and data shall be stored in nonvolatile memory in the event of power loss.

2.7 Steam Flow Meters

A. Vortex Shedding Flow Meter with Integral Pressure and Temperature Measurement:
   1. Description:
      a. Mass flow measurement corrected for density using vortex shedder body with integral piezoelectric pressure sensors and 1000-ohm platinum RTD.
      b. Meter NPS 1/2 through NPS 12.
      c. Each meter shall be factory calibrated at five points from Zero to 250 fps and tagged accordingly against the manufacturer's flow standards. The manufacturer shall provide a certificate of calibration for meter.
      d. Each meter shall be programmed using project-specific application data.
      e. Meter shall include integral diagnostics to verify installation conditions and proper operation.
   2. Performance:
      a. Volumetric Flow Accuracy for Liquid: Within 0.75 percent of reading for Reynolds numbers 20000 and larger.
      b. Volumetric Flow Accuracy for Steam and Gas: Within 1 percent of reading for Reynolds numbers 20000 and larger.
      c. Mass Flow Accuracy for Steam and Gas: Within 1.5 percent of reading for Reynolds numbers 20000 and larger.
      d. Repeatability: Within 0.1 percent.
      e. Long-Term Stability: Within 0.1 percent per year.
      f. Ambient Temperature: Minus 40 to plus 185 deg F.
      g. Process Temperature: Minus 40 to plus 464 deg F.
      h. Pressure: Equal to flange rating.
3. **Output Signals:**
   a. **Analog Current Signal of Flow Rate:**
      1) Two-wire, 4- to 20-mA dc current source.
      2) Signal capable of operating into 1000-ohm load.
   b. **Analog Current Signals for Pressure and Temperature:** Separate 4- to 20-mA signals for gage pressure and temperature.
   c. **Digital Signal:**
      1) Pulse output for flow totalization. Two wire, scaled pulse, 0.5 Hz, 100 mA at 30-V dc.
      2) HART, FSK protocol.

4. **Operator Interface:**
   a. Keypad.
   b. Digital Display: Two-line digital display of alphanumerical characters. The meter shall display flow rate, flow totalization, pressure, temperature, and support field programming of all parameters.

5. **Construction:**
   a. Material: Type 316L stainless steel.
   b. Connection: Class 150 flange.
   c. Enclosure:
      1) Epoxy-painted cast aluminum.
      2) Removable screw-on cover.
      3) NEMA 250, Type 6.
      4) Electrical Connection: Screw terminals.
      5) Conduit Connection: Two, 1/2-inch trade size.

6. **Upstream Flow Straightener:**
   a. Meter manufacturer shall provide flow straightener where required by installation to comply with manufacturer’s installation recommendations.
   b. Straightener shall be wafer type, constructed of Type 304 stainless steel, designed to be installed between field-installed flanges.
   c. Straightener size shall match meter size.

**2.8 LIQUID FLOW SENSORS (PRIMARY ELEMENTS)**

A. **Averaging Pitot Tubes:**
   1. Onicon
   2. Standards: ASME MFC-12M.
   3. **Description:**
      a. Sensor shall include isolation valves and connections that are suitable for connecting to a remote pressure instrument.
b. Sensor shall consist of high- and low-pressure plenums and be able to accommodate an integral RTD.

c. Sensor's cross-sectional tee shape shall allow flow separation at a fixed point independent of flow rate, pressure, or temperature with a stable flow coefficient maintained over a wide range of Reynolds numbers.

d. Sensor shape shall promote less-turbulent zones on the backside of the sensor. Individual sensing ports shall be located in this less-turbulent region to measure low pressure. Number of sensing ports shall be a function of the pipe size.

e. High pressure shall be measured by a frontal slot design extending full length of sensor. Number of slots shall be a function of pipe size.

f. Manufacturer shall submit on request independent testing documentation (product test reports), demonstrating compliance with specified performance.

4. Performance: Product test reports are required.

a. Discharge Coefficient Factor: Within 0.75 percent of flow rate.

b. Repeatability: Within 0.1 percent.


d. Sensor Size for Pipe Size NPS 2 through NPS 8: Minimum rod Reynolds number of 6000; probe width of 0.59 inch.

e. Sensor Size for Pipe Size NPS 6 through NPS 36: Minimum rod Reynolds number of 12500; probe width of 1.060 inch.

f. Sensor Size for Pipe Size NPS 12 through NPS 72: Minimum rod Reynolds number of 25000; probe width of 1.953 inches.

g. Process Temperature Limit: 500 deg F.

h. Process Pressure Limit: Equal to flange rating.

5. Construction:

a. Sensor Surface Finish: Front surface textured for high-Reynolds-number applications to create a more turbulent boundary layer on front surface of sensor and produce a more predictable and repeatable separation of flow at edge of sensor.

b. Sensor Material: Type 316 stainless steel.

c. Packing Gland:

   1) Wetted Parts: Type 316 stainless steel.
   2) Packing Material: Graphite.

d. Isolation Valve: Type 316 stainless-steel full port ball valve configured to remove sensor while isolating process.

e. Flanged In-line Pipe Spool:

   1) Mount sensor in a flanged section of pipe.
   2) Pipe material to match adjacent pipe.
   3) Flanges to match adjacent pipe.

2.9 LIQUID FLOW SENSORS (PRIMARY ELEMENTS)

A. Venturis:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. HCl
b. Preso Meters

2. On request, submit independent testing documentation (product test reports), demonstrating compliance with specified performance.

3. Standard: ASME MFC-3M.

4. Performance:
   a. Accuracy within 0.5 percent of measured flow throughout flow range from design to 10 percent of design flow.
   b. Accuracy with five pipe diameters of straight pipe upstream and two pipe diameters downstream.
   c. Size and beta ratio shall be matched with transmitter to provide accuracy of entire assembly within 1 percent of design flow rate, when the flow rate is allowed to vary between 10 to 100 percent of the design.

5. Construction:
   a. One-piece bronze or brass construction with threaded connections for pipe sizes NPS 1/2 through NPS 2.
   b. One-piece plated cast steel with flanged connections for pipe sizes NPS 2-1/2 through NPS 8, and fabricated steel with flanged connections for larger sizes.
   c. Sensing Taps: Two, accurately located built-in sensing taps, nipples, shut-off valves, and quick connect coupling.
   d. Identification Tag: Attached to each venturi with a chain and label indicating pipe size, venturi series, station identification, and meter reading at flow rate and pressure differential.
   e. Use venturi with pressure differential transmitter.

B. Orifice Plates:

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

2. Standards: ASME MFC-3M or ASME MFC-14M.

3. Performance:
   a. Orifice plates shall be sharp, square-edged concentric type.
   b. Shop fabricate and calibrate orifice meter runs through NPS 2.
   c. Field fabricate orifice runs NPS 3 and larger.
   d. Meter run piping or tubing shall be uniform internal surface, which is free of internal grooves and striations, but is not polished. Out of roundness shall not exceed 0.5 percent. A reduction of the pipe diameter or distortion caused by welding is unacceptable.
   e. Size orifice plates for 100-inch wg pressure differential, except that the absolute value of the meter range shall not exceed the absolute value of the flowing pressure.
   f. Ratio of orifice diameter to actual internal pipe diameter d/B (beta) shall be between 0.70 and 0.30.
   g. Locate orifice plates in horizontal or vertical lines in accordance with good metering practice.
   h. Minimum upstream and downstream straight pipe shall comply with ASME Fluid Meters Research Committee Reports.
a. Fabricate the orifice plate and matching companion flanges of Type 316 stainless steel.
b. Transmitter connection shall be at least NPS 1/2.
c. Stamp the orifice plates with the number and the orifice bore on the handle of the plate.

5. Use orifice plate with pressure differential transmitter.
6. Calibration information and calculations shall comply with either of the referenced standards for each orifice plate.

C. Portable Meter Package for Liquid Flow Sensors:

1. Metal-reinforced-plastic carrying case.
2. Waterproof meter with nominal 6-inch round dial face.
4. Meter with external range and zero adjustment.
5. Multiple meters in package, if required to accommodate venturis with a wide range of pressure signals.
6. Two connecting hoses, 10-feet long, with quick connect couplings compatible with venturi couplings.
7. Two brass blowdown valves with Buna-N seals and blowdown hoses.
9. Suitable for working pressure of 200 psig at 200 deg F.
10. Portable meter package to connect to flow sensor without disturbing connection to pressure differential transmitter. Provide isolation valves at connections.
11. Turn over to Owner at Project completion.

2.10 LIQUID FLOW SWITCHES

A. Liquid Flow Switch (Bellows Type):

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

2. Description:
   a. Field-adjustable four-vane combinations.
   b. Field-adjustable set-point adjustment screw.
   c. Suitable for pipe sizes NPS 1 through NPS 8.
   d. Switch mounted vertically in horizontal pipe.

3. Performance:
   a. Flow Rate Actuation and De-actuation: Varies with vane combination and set-point adjustment.
   c. Temperature Limit: 230 deg F.
   d. Electrical Rating: 10 A resistive, 3 A conductive at 250-V ac.
   e. Switch Type: SPDT snap switch.

4. Wetted Parts Construction:
b. Vanes: Stainless steel.
c. Body: Forged brass.

5. Enclosure:
   a. Die-cast aluminum alloy.
   b. NEMA 250, Type 4.
   c. Electrical Connection: Cable gland with attached wire leads.

B. Liquid Flow Switch (Magnetic Type):
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. W.E. Anderson
   2. Description:
      a. Field-adjustable five-vane combinations.
      b. Suitable for pipe sizes NPS 1-1/2 through NPS 20.
      c. Mounting Suitable for Application: Switch vertically mounted in horizontal pipe, or switch horizontally mounted in vertical pipe with flow up.
      d. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for hazardous-environment Class I, Groups C and D; Class II, Groups E, F, and G.
   3. Performance:
      a. Flow Rate Actuation and De-actuation: Varies with vane combination.
      b. Pressure Limit: 1000 psig for brass body, 2000 psig for Type 316 stainless-steel body.
      c. Temperature Range: Minus 4 to plus 275 deg F.
      d. Electrical Rating: 10 A at 125/250-V ac.
      e. Switch Type: SPDT snap switch.
   4. Wetted Parts Construction:
      a. Vanes: Type 316 stainless steel.
      b. Body: Type 316 stainless steel.
      c. Magnetic Keeper: Type 316 stainless steel.
   5. Enclosure:
      a. Die-cast aluminum alloy.
      b. Threaded cover.
      c. NEMA 250, Type 4.
      d. Electrical Connection: Terminal block.
      e. Conduit Connection: 3/4-inch trade size.

2.11 LIQUID FLOW TRANSMITTERS

A. Liquid Pressure Differential Transmitter for Flow Measurement:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Dwyer Instruments, Inc.

2. Performance:
   a. Range: Approximately 2 times the set point.
   b. Span: Adjustable plus or minus 1 mA, non-interactive.
   c. Accuracy: Within 0.25 percent of full scale.
   d. Maximum Operating Pressure: 2.5 times range.
   e. Temperature Limits: Zero to 175 deg F.
   f. Compensate Temperature Limits: 30 to 150 deg F.
   g. Thermal Effects: 0.02 percent of full scale per degree F.
   h. Response Time: 30 to 50 ms.
   i. Shock and vibration shall not harm the transmitter.

3. Analog Output Current Signal:
   a. Two wire, 4- to 20-mA dc current source.
   b. Signal capable of operating into 1000-ohm load.

4. Operator Interface:
   a. Zero and span adjustments located behind cover.
   b. Bleed screws on side of body, two screws on low-pressure side and one screw on high-pressure side, for air in line and pressure cavity.

5. Construction:
   a. Aluminum and stainless-steel enclosure with removable cover.
   b. Wetted parts of transmitter constructed of 17-4 PH or 300 series stainless steel.
   c. NPS 1/4 process connections on side of instrument enclosure.
   d. Knock out for 1/2-inch trade size conduit connection on side of instrument enclosure.
   e. Screw terminal block for wire connections.
   f. NEMA 250, Type 4X.
   g. Mounting bracket shall be suitable for installation.

6. Transmitter shall have three-valve manifold. Construct manifold of brass, bronze, or stainless steel. Manifold shall have NPS 1/4 process connections.

PART 3 - EXECUTION

3.1 INSTRUMENT APPLICATIONS

A. Select from instrument types to achieve performance requirements and characteristics indicated while subjected to full range of system operation encountered.

B. Duct-Mounted Airflow Sensors:

C. Damper-Mounted Airflow Sensors:
   1. Measured Velocities 400 fpm and Less: Thermal airflow station.

D. Fan-Mounted Airflow Sensors:

E. Airflow Switches:

F. Liquid Flow Meters:

G. Steam Flow Meters: Vortex Shedding flow meter:

3.2 INSTALLATION, GENERAL

A. Furnish and install products required to satisfy more stringent of all requirements indicated.

B. Install products level, plumb, parallel, and perpendicular with building construction.

C. Properly support instruments, tubing, piping wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to a seismic force.

D. Install ceiling, floor, roof, and wall openings and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

E. Install products in locations that are accessible and that will permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner’s access, confirm unrestricted ladder placement is possible under occupied condition.

F. Corrosive Environments:
   1. Use products that are suitable for environment to which they will be subjected.
   2. If possible, avoid or limit use of materials in corrosive environments, including, but not limited to, the following:
      a. Laboratory exhaust airstreams.
   3. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings with a corrosive-resistant coating that is suitable for environment.
4. Where instruments are located in a corrosive environment and are not corrosive resistant from the manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.3 ELECTRIC POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 26 28 16 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 26 05 33 "Raceways and Boxes for Electrical Systems."

3.4 INSTRUMENTS, GENERAL INSTALLATION REQUIREMENTS

A. Mounting Location:

1. Rough-in: Outline instrument-mounting locations before setting instruments and routing cable, wiring, tubing, and conduit to final location.

2. Install switches and transmitters for air and liquid flow associated with individual air-handling units and connected ductwork and piping near air-handlings units co-located in air-handling unit system control panel, to provide service personnel a single and convenient location for inspection and service.

3. Install liquid and steam flow switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.

4. Install airflow switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.

5. Mount switches and transmitters not required to be mounted within system control panels on walls, floor-supported freestanding pipe stands, or floor-supported structural support frames. Use manufacturer mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.

6. Install instruments in steam, liquid, and liquid-sealed-piped services below their process connection point. Slope tubing down to instrument with a slope of 2 percent.

7. Install instruments in dry gas and non-condensable-vapor piped services above their process connection point. Slope process connection lines up to instrument with a minimum slope of 2 percent.

B. Mounting Height:

1. Mount instruments in user-occupied space to match mounting height of light switches unless otherwise indicated on Drawings. Mounting height shall comply with codes and accessibility requirements.

2. Mount switches and transmitters, located in mechanical equipment rooms and other similar space not subject to code, state, and federal accessibility requirements, within a range of 42 to 72 inches above the adjacent floor, grade, or service catwalk or platform.

   a. Make every effort to mount at 60 inches.
C. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static-pressure class and leakage and seal classes indicated using neoprene gaskets or grommets.

3.5 FLOW INSTRUMENTS INSTALLATION

A. Airflow Sensors:
   1. Install sensors in straight sections of duct with manufacturer-recommended straight duct upstream and downstream of sensor.
   2. Installed sensors shall be accessible for visual inspection and service. Install access door(s) in duct or equipment located upstream of sensor, to allow service personnel to hand clean sensors.

B. Liquid and Steam Sensors:
   1. Install sensors in straight sections of piping with manufacturer-recommended straight piping upstream and downstream of sensor.
   2. Alert manufacturer where installation cannot accommodate recommended clearance, and solicit recommendations for field modifications to installation, such as flow straighteners, to improve condition.
   3. Install pipe reducers for in-line sensors smaller than line size. Position reducers at distance from sensor to avoid interference and impact on accuracy.
   4. Install in-line sensors with flanges or unions to provide drop-in and -out installation.

C. Liquid Flow Meters:
   1. Install meters in straight sections of piping with manufacturer-recommended straight piping upstream and downstream of sensor.
   2. Install pipe reducers for in-line meters smaller than line size. Install reducers at distance from meter to avoid interference and impact on accuracy.
   3. Install in-line meters with flanges or unions to provide drop-in and -out installation.
   4. Insertion Meters:
      a. Install system process connections full size of meter connection, but not less than NPS 2. Provide stainless-steel bushing if required to mate to system connection.
      b. Install meter in top dead center of horizontal pipe positioned in an accessible location to allow for inspection and replacement.
      c. In applications where top-dead-center location is not possible due to field constraints, install meter at location along top half of pipe if acceptable by manufacturer for mounting orientation.

D. Liquid Switches:
   1. Install system process connection full size of switch connection, but not less than NPS 2. Install stainless-steel bushing if required to mate switch to system connection.
   2. Install switch in top dead center of horizontal pipe positioned in an accessible location to allow for inspection and replacement.
   3. In applications where top-dead-center location is not possible due to field constraints, install switch at location along top half of pipe if switch is acceptable by manufacturer for mounting orientation.

E. Transmitters:
1. Install airflow transmitters serving an air system in a single location adjacent to or within system control panel.
2. Install liquid flow transmitters, not integral to sensors, in vicinity of sensor. Where multiple flow transmitters serving same system are located in same room, co-locate transmitters by system to provide service personnel a single and convenient location for inspection and service.

3.6 IDENTIFICATION
A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."
B. Install engraved phenolic nameplate with instrument identification[ and on face of ceiling directly below instruments concealed above ceilings].

3.7 CHECKOUT PROCEDURES
A. Description:
   1. Check out installed products before continuity tests, leak tests, and calibration.
   2. Check instruments for proper location and accessibility.
   3. Check instruments for proper installation with respect to direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.
   4. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material, and support.
B. Flow Instrument Checkout:
   1. Verify that sensors are installed correctly with respect to flow direction.
   2. Verify that sensor attachment is properly secured and sealed.
   3. Verify that processing tubing attachment is secure and isolation valves have been provided.
   4. Inspect instrument tag against approved submittal.
   5. Verify that recommended upstream and downstream distances have been maintained.

3.8 DEMONSTRATION
A. Train Owner's maintenance personnel to adjust, operate, and maintain instrumentation and control devices.
B. Coordinate video with operation and maintenance manuals and classroom instruction for use by Owner in operating, maintaining, and troubleshooting.
C. Record videos on DVD disks.
D. Owner shall have right to make additional copies of video for internal use without paying royalties.

END OF SECTION 23 09 23.14
SECTION 23 09 23.16 - GAS INSTRUMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes the Following Gas Instruments:
   2. VOC sensors and transmitters.

B. Related Requirements:
   1. Section 23 09 23 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.
   2. Section 23 09 93 "Sequence of Operations for HVAC Controls" for requirements that relate to Section 23 09 23.16.

1.2 DEFINITIONS

A. NDIR: Nondispersive infrared.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.


C. Shop Drawings:
   1. Include plans, elevations, sections, and mounting details.
   2. Include diagrams for power, signal, and control wiring.
   3. Number-coded identification system for unique identification of wiring, cable, and tubing ends.

PART 2 - PRODUCTS

2.1 CARBON-DIOXIDE SENSORS AND TRANSMITTERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Building Automation Products
   2. Telaire
   3. Vaisala
   4. Veris Industries

B. Description:
1. NDIR technology or equivalent technology providing long-term stability and reliability.
2. Two-wire, 4-20 mA output signal, linearized to carbon-dioxide concentration in ppm.

C. Construction:

1. House electronics in an ABS plastic enclosure. Provide equivalent of NEMA 250, Type 1 enclosure for wall-mounted space applications and NEMA 250, Type 4 for duct-mounted applications.
2. Equip with digital display for continuous indication of carbon-dioxide concentration.

D. Performance:

2. Accuracy: Within 2 percent of reading, plus or minus 30 ppm.
3. Repeatability: Within 1 percent of full scale.
4. Temperature Dependence: Within 0.05 percent of full scale over an operating range of 25 to 110 deg F.
5. Long-Term Stability: Within 5 percent of full scale after more than five years.
6. Response Time: Within 60 seconds.
7. Warm-up Time: Within five minutes.

E. Provide calibration kit. Turn over to Owner at start of warranty period.

2.2 VOC SENSORS AND TRANSMITTERS

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

1. Building Automation Products

B. Description:

1. VOC sensor shall use an oxidizing element that varies resistance with contaminant gases.
2. Senses and responds to combined concentration of more than 30 contaminates commonly found in indoor environments.

C. Output Signal: Zero to 5 or 10-V dc with minimum load resistance of 4000 ohms.

D. Performance:

1. Measurement Range: Zero to 100 percent.
2. Ambient Temperature: 32 to 140 deg F.
3. Ambient Relative Humidity: 5 to 95 percent non-condensing.

E. Enclosure: Lexan.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Furnish and install products required to satisfy more stringent of all requirements indicated.
B. Install products level, plumb, parallel, and perpendicular with building construction.

C. Properly support instruments, tubing, piping, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to seismic loads.

D. Fastening Hardware:
   1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
   2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by using excessive force or oversized wrenches.
   3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

E. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

F. Corrosive Environments:
   1. Use products that are suitable for environment to which they are subjected.
   2. If possible, avoid or limit use of materials in corrosive environments, including but not limited to, the following:
      a. Laboratory exhaust airstreams.
      b. Process exhaust airstreams.
   3. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
   4. Where instruments are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.2 ELECTRICAL POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 26 28 16 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 26 05 33 "Raceways and Boxes for Electrical Systems."

3.3 INSTRUMENTS, GENERAL INSTALLATION REQUIREMENTS

A. Mounting Location:
1. Install transmitters for gas associated with individual air-handling units and associated connected ductwork and piping near air-handlings units co-located in air-handling unit system control panel, to provide service personnel a single and convenient location for inspection and service.

2. Install gas switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.

3. Mount switches and transmitters not required to be mounted within system control panels on walls, floor-supported freestanding pipe stands, or floor-supported structural support frames. Use manufacturer’s mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.

4. Install instruments in dry gas and non-condensable vapor piped services above their process connection point. Slope process connection lines up to instrument with a minimum slope of 2 percent.

B. Mounting Height:

1. Mount instruments in user-occupied space to match mounting height of light switches unless otherwise indicated on Drawings. Mounting height shall comply with codes and accessibility requirements.

2. Mount switches and transmitters located in mechanical equipment rooms and other similar space not subject to code, state, and federal accessibility requirements within a range of 42 to 72 inches above the adjacent floor, grade, or service catwalk or platform.

   a. Make every effort to mount at 60 inches.

C. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static-pressure class and leakage and seal classes indicated, using neoprene gaskets or grommets.

3.4 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

B. Install engraved phenolic nameplate with instrument identification on face.

3.5 CHECKOUT PROCEDURES

A. Check out installed products before continuity tests, leak tests, and calibration.

B. Check instruments for proper location and accessibility.

C. Check instruments for proper installation on direction of flow, elevation, orientation, insertion depth, or other applicable considerations that impact performance.

D. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material, and support.

3.6 DEMONSTRATION

A. Train Owner’s maintenance personnel to adjust, operate, and maintain instrumentation and control devices.
B. Coordinate gas instrument demonstration video with operation and maintenance manuals and classroom instruction for use by Owner in operating, maintaining, and troubleshooting.

C. Record videos on DVD disks.

D. Owner shall have right to make additional copies of video for internal use without paying royalties.

END OF SECTION 23 09 23.16
SECTION 23 09 23.17 - LEVEL INSTRUMENTS

PART 1 - GENERAL

1.1 SUMMARY
A. Section includes liquid-level switches, sensors, and transmitters.
B. Related Requirements:
   1. Section 23 09 23 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.
   2. Section 23 09 93 "Sequence of Operations for HVAC Controls" for requirements that relate to Section 23 09 23.17.

1.2 ACTION SUBMITTALS
A. Product Data: For each type of product.
B. Shop Drawings:
   1. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   2. Include diagrams for power, signal, and control wiring.
   3. Include number-coded identification system for unique identification of wiring, cable, and tubing ends.

1.3 CLOSEOUT SUBMITTALS
A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 LEVEL SWITCHES
A. Liquid-Level Switch (Magnetic Type with Float):
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. W.E. Anderson
   2. Description:
      a. Mounting Suitable for Application: Horizontal or vertical switch mounting.
      b. Float arm with hinge design limits vertical movement to prevent sticking.
      c. Replaceable float with threaded connection.
d. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for hazardous environments (Class I, Groups C and D; Class II, Groups E, F, and G).

3. Performance:
   a. Level Actuation and De-Actuation: 0.75-inch deadband.
   b. Body Pressure Limit: 1000 psig for brass body; 2000 psig for Type 316 stainless-steel body.
   c. Float Pressure Limit: 150 psig.
   d. Temperature Range: Minus 4 to 275 deg F.
   e. Electrical Rating: 10 A at 125/250-V ac.
   f. Switch Type: SPDT snap switch.

4. Wetted Parts Construction:
   a. Float and Rod: Type 316 stainless steel.
   b. Body: Type 316 stainless steel.
   c. Magnetic Keeper: Type 316 stainless steel.
   d. Process Connection: NPS 1-1/2 NPT.
   e. Enclosure:
      1) Die-cast aluminum alloy.
      2) Threaded cover.
      3) NEMA 250, Type 4.
      4) Electrical Connection: Terminal block.
      5) Conduit Connection: NPS 3/4 NPT.

B. Electrode-Type Liquid-Level Switches:

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

2. Description:
   a. Conductivity technology.
   b. Dual point level settings.
   c. No moving parts.
   d. Adjustable sensitivity.

3. Performance:
   a. Pressure Limit: 30 psig.
   b. Temperature Limit: 212 deg F.
   c. Power Supply: 120-V ac, 50 or 60 Hz.
   d. Electrical Rating: 5 A at 240-V ac.
   e. Switch Type: SPDT snap switch.

4. Probes:
   a. Electrodes: 0.125-inch diameter.
   b. Material: Type 316 stainless steel.
   c. Length: To suit application up to 72 inches.
d. Process Connection: NPS 1 NPT.

e. Enclosure:

1) Polypropylene.
2) NEMA 250, Type 6.
3) Electrical Connection: Cable and standard octal socket.

2.2 LEVEL TRANSMITTERS

A. RF Admittance-Type Liquid-Level Sensor and Transmitter:

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

a. AMETEK, Inc.

2. Description: Complete package with electronic unit, sensing element, connecting cable.

a. Continuous level transmitter shall produce an output signal that is proportional to level.
b. Measurement shall be free from effects of changes in temperature, density, or acoustic noise in vapor space above level.
c. Continuous measurement shall be independent of changes in material density and unaffected by presence of material clinging to sensing element.
d. No moving parts and no routine cleaning and recalibration necessary.
e. Electronic unit shall be integral to sensing element or mounted remotely up to 100 feet away from sensor.
f. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for hazardous environments (Class I, Groups C and D; Class II, Groups E, F, and G).

3. Sensor:

a. Material: Teflon-coated Type 316 stainless steel.
b. Length: To suit installation.
c. Connection: NPS 3/4 NPT or flanged.

4. Electronic unit housed in NEMA 250, Type 4X enclosure.

a. Calibrated Range: Varies with application. At least 10 percent beyond high- and low-level set point and alarm levels.
b. Accuracy: Within 1 percent of calibrated range.
c. Two wire, loop powered.
d. Supply Voltage: 11.5 to 50-V dc.
e. Maximum Load: 625 ohms at 24-V dc.
f. Output Signal: 4 to 20 mA dc.
g. Response Time: 0.5 to 30 seconds, adjustable.
h. Temperature Range: Minus 40 to 165 deg F.
j. Visual Indication: Continuous digital display of level.
k. Field-changeable failsafe condition and phasing in event measurement requires changes to optimize level reading.
l. Free from effects of radio frequency interference.
m. Free from harmful effects of static electricity on sensing element with discharges of up to 10 A without damage.
n. Adjustable time delay (signal dampening).

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Install products level, plumb, parallel, and perpendicular with building construction.

B. Properly support instruments, tubing, piping, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement, sway, or a break in attachment when subjected to a seismic force.

C. Fastening Hardware:
   1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
   2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by using excessive force or oversized wrenches.
   3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

D. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

E. Mount switches and transmitters not subject to code, state, and federal accessibility requirements within a range of 42 to 72 inches above the adjacent floor, grade or service catwalk, or platform.
   1. Make every effort to mount at 60 inches.

F. Corrosive Environments:
   1. Use products that are suitable for environment to which they are subjected.
   2. If possible, avoid or limit use of materials in corrosive environments.
   3. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
   4. Where instruments are located in a corrosive environment and are not corrosion resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.2 ELECTRICAL POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 26 28 16 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."
D. Furnish and install raceways. Comply with requirements in Section 26 05 33 "Raceways and Boxes for Electrical Systems."

3.3 LEVEL INSTRUMENTS INSTALLATION

A. Mounting Location: Rough-in instrument-mounting locations before setting instruments and routing, cable, wiring, tubing, and conduit to final location.

3.4 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

B. Install engraved phenolic nameplate with instrument identification on face.

3.5 CHECKOUT PROCEDURES

A. Check out installed products before continuity tests, leak tests, and calibration.

B. Check instruments for proper location and accessibility.

C. Check instruments for proper installation on direction of elevation, orientation, insertion depth, or other applicable considerations that impact performance.

3.6 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain instrumentation and control devices.

B. Coordinate level instrument demonstration video with operation and maintenance manuals and classroom instruction for use by Owner in operating, maintaining, and troubleshooting.

C. Record videos on DVD disks.

D. Owner shall have right to make additional copies of video for internal use without paying royalties.

END OF SECTION 23 09 23.17
SECTION 23 09 23.22 - POSITION INSTRUMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes position limit switches for use in direct-digital control systems for HVAC.

B. Related Requirements:
   1. Section 23 09 23 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.
   2. Section 23 09 93 "Sequence of Operations for HVAC Controls" for requirements that relate to Section 23 09 23.22.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:
   1. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   2. Include diagrams for power, signal, and control wiring.
   3. Include number-coded identification system for unique identification of wiring.

PART 2 - PRODUCTS

2.1 POSITION LIMIT SWITCHES

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

B. Description: Select type of actuating head (plunger, roller lever, or rod) to suit application.
   1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Performance:
   1. Life expectancy: Not less than 30 million mechanical operations and 750,000 electrical operations.
   2. Operating Frequency: 300 mechanical operations per minute and 30 electrical operations per minute.
   3. Voltage: 125-, 250-, 480-, and 600-V ac or 8-, 12-, 14-, 24-, 30-, 48-, 125-, and 250-V dc, as required by application.
5. Temperature Rise: 50 deg C.
6. Ambient Temperature: 14 to 175 deg F.
7. Ambient Relative Humidity: 35 to 95 percent.

D. Construction:

1. NEMA 250, Type 4X enclosure.
2. Switch Type: SPDT or DPDT, as required by application.
3. Status indicator integral to switch. Field switchable to light when contacts are actuated and operating, or contacts are free and not operating.
4. Electrical Connection: Screw or plug-in terminals.
5. Conduit Connection: NPS 1/2.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Install products level, plumb, parallel, and perpendicular with building construction.

B. Properly support instruments, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement, sway, or a break in attachment when subjected to a seismic force.

C. Fastening Hardware:

1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not to overstress threads by using excessive force or oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

D. Install products in locations that are accessible and that permit maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

E. Corrosive Environments:

1. Use products that are suitable for environment to which they are subjected.
2. If possible, avoid or limit use of materials in corrosive environments, including, but not limited to:
   a. Laboratory exhaust airstreams.
   b. Process exhaust airstreams.
3. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
4. Where instruments are located in a corrosive environment and are not corrosive resistant from the manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.
3.2 ELECTRICAL POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 26 28 16 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 26 05 33 "Raceways and Boxes for Electrical Systems."

3.3 POSITION INSTRUMENTS INSTALLATION

A. Mounting Location:

1. Rough-in instrument-mounting locations before setting instruments and routing, cable, wiring, and conduit to final location.
2. Use manufacturer mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.

B. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static-pressure class and leakage and seal classes indicated, using neoprene gaskets or grommets.

END OF SECTION 23 09 23.22
PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Air-pressure sensors.
2. Air-pressure switches.
3. Air-pressure transmitters.
4. Liquid-pressure switches.
5. Liquid-pressure transmitters.

B. Related Requirements:

1. Section 23 09 23 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.
2. Section 23 09 93 "Sequence of Operations for HVAC Controls" for requirements that relate to Section 23 09 23.23.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Include plans, elevations, sections, and mounting details.
2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Number-coded identification system for unique identification of wiring, cable, and tubing ends.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 AIR-PRESSURE SENSORS

A. Duct Insertion Static Pressure Sensor:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Dwyer Instruments, Inc.

2. Insertion length shall be at 4 inches.
3. Sensor with four radial holes of 0.04-inch diameter.
4. Brass or stainless-steel construction.
5. Sensor with threaded end support, sealing washers and nuts.
7. Suitable for flat oval, rectangular, and round duct configurations.

B. Outdoor Static Pressure Sensor:

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

2. Provides average outdoor pressure signal.
3. Sensor with no moving parts.
4. Kit includes sensor, vinyl tubing mounting hardware.

C. Space Static Pressure Sensor for Wall Mounting:

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

2. 100-micron filter mounted in stainless-steel wall plate senses static pressure.
3. Wall plate provided with gasket and screws, and sized to fit standard single-gang electrical box.
4. Back of sensor plate fitted with brass barbed fitting for tubing connection.

D. Space Static Pressure Sensor for Recessed Ceiling Mounting:

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

2. Aluminum round plate with perforated center arranged to sense space static pressure. Exposed surfaces provided with brush finish.
3. Sensor intended for flush mount on face of ceiling with pressure chamber recessed in ceiling plenum.
4. Back of sensor plate fitted with multiple sensing ports, pressure impulse suppression chamber, airflow shielding, and 0.125-inch fitting for concealed tubing connection.
5. Performance: Within 1 percent of actual room static pressure in vicinity of sensor while being subjected to an air velocity of 1000 fpm from a 360 degree radial source.

2.2 AIR-PRESSURE SWITCHES

A. Air-Pressure Differential Switch:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Dwyer Instruments, Inc.

2. Diaphragm operated to actuate an SPDT snap switch.

3. Electrical Connections: Three-screw configuration, including one screw for common operation and two screws for field-selectable normally open or closed operation.

4. Enclosure Conduit Connection: Knock out or threaded connection.

5. User Interface: Screw-type set-point adjustment located inside removable enclosure cover.


7. Enclosure:
   a. Dry Indoor Installations: NEMA 250, Type 1.
   b. Outdoor and Wet Indoor Installations: NEMA 250, Type 4.
   c. Hazardous Environments: Explosion proof.

8. Operating Data:
   a. Electrical Rating: 15 A at 120- to 480-V ac.
   b. Pressure Limits:
      1) Continuous: 45 inches wg.
      2) Surge: 10 psig.
   c. Temperature Limits: Minus 30 to 180 deg F.
   d. Operating Range: Approximately 2 times set point.
   e. Repeatability: Within 3 percent.
   f. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.3 AIR-PRESSURE TRANSMITTERS

A. Air-Pressure Differential Transmitter:

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

2. Performance:
   a. Range: Approximately 2 times set point.
   b. Accuracy: Within 0.5 percent of the span at reference temperature of 70 deg F.
   c. Hysteresis: Within 0.02 percent of the span.
   d. Repeatability: Within 0.05 percent of the calibrated span.
   e. Stability: Within 0.25 percent of span per year.
   f. Overpressure: 15 psig.
   g. Temperature Limits: Minus 20 to 160 deg F.
   h. Compensate Temperature Limits: 35 to 135 deg F.
i. Thermal Effects: 0.015 percent of full scale per degree F.
j. Warm-up Time: Within 5 seconds.
k. Response Time: 250 ms.
l. Shock and vibration shall not harm the transmitter.

3. Output Signals:
   a. Analog Current Signal:
      1) Two-wire, 4- to 20-mA dc current source.
      2) Signal capable of operating into 1000-ohm load.
   b. Analog Voltage Signal:
      1) Three wire, zero to 5 V.
      2) Minimum Load Resistance: 1000 ohms.

4. Operator Interface:
   a. Zero and span adjustments within 10 percent of full span.
   b. Potentiometer adjustments located on face of transmitter.

5. Construction:
   a. Type 300 stainless-steel enclosure.
   b. Swivel fittings for connection to copper tubing or barbed fittings for connection to polyethylene tubing. Fittings on front of instrument enclosure.
   c. Screw terminal block for wire connections.
   d. Vertical plane mounting.
   e. NEMA 250, Type 2.
   f. Mounting Bracket: Appropriate for installation.
   g. Reverse wiring protected.
   h. Calibrate to NIST-traceable standards and provide each transmitter with a certificate of calibration.

B. Air-Pressure Differential Indicating Transmitter:

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

2. Performance:
   a. Range: Approximately 2 times set point.
   b. Accuracy Including Hysteresis and Repeatability: Within 1 percent of full scale at 77 deg F.
   c. Stability: Within 1 percent of full scale per year.
   d. Overpressure: 10 psig.
   e. Temperature Limits: 20 to 120 deg F.
   f. Thermal Effects: 0.055 percent of full scale per degree F.

3. Display: Four-digit digital display with minimum 0.4-inch-high numeric characters.

4. Operator Interface:
a. Zero and span adjustments.
b. Selectable engineering units.

5. Analog Output Current Signal:
   a. Two-wire, 4- to 20-mA dc current source.
   b. Signal capable of operating into a 1200-ohm load.

6. Construction:
   a. Plastic casing with clear plastic cover.
   b. Integral fittings for plastic tubing connections on side of instrument case for high- and low-pressure connections.
   c. Terminal block for wire connections.
   d. Vertical plane mounting.
   e. NEMA 250, Type 1.
   f. Nominal 4-inch diameter face.
   g. Mounting Bracket: Appropriate for installation.

2.4 LIQUID-PRESSURE SWITCHES

A. Liquid Gage Pressure Switch, Diaphragm Operated, Low Pressure:

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

2. Description:
   a. Diaphragm operated to actuate an SPDT snap switch.
   b. Electrical Connections: Screw terminal.
   c. Enclosure Conduit Connection: Knock out or threaded connection.
   d. User Interface: External screw with visual set-point adjustment.
   f. Enclosure:
      1) Dry Indoor Installations: NEMA 250, Type 1.
      2) Outdoor and Wet Indoor Installations: NEMA 250, Type 4.
      3) Hazardous Environments: Explosion proof.

3. Operating Data:
   a. Electrical Rating: 15 A at 120-V ac.
   b. Pressure Limits:
      1) Range 1 to 30 psig: 60 psig.
      2) Range 10 to 125 psig: 160 psig.
   c. Temperature Limits: Minus 30 to 150 deg F.
   d. Operating Range: 10 to 250 psig.
   e. Deadband: Fixed.
4. Pressure Chamber Material: Stainless steel.
5. Diaphragm Material: Nylon or PTFE.

B. Liquid-Pressure Differential Switch with Set-Point Indicator:

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

2. Description:
   a. Type 316 stainless steel double opposing bellows operate to actuate a SPDT snap switch.
   b. Electrical Connections: Screw terminal.
   c. Enclosure Conduit Connection: Knock out or threaded connection.
   d. User Interface: Thumbscrew set-point adjustment with enclosed set-point indicator and scale.
   f. Enclosure:
      1) Dry Indoor Installations: NEMA 250, Type 1.
      2) Outdoor and Wet Indoor Installations: NEMA 250, Type 4.
      3) Hazardous Environments: Explosion proof.
   g. Operating Data:
      1) Electrical Rating: 15 A at 120- to 240-V ac.
      2) Pressure Limits: At least 5 times full-scale range, but not less than system design pressure rating.
      3) Temperature Limits: Minus 10 to 180 deg F.
      4) Operating Range: Approximately 2 times set point.
      5) Deadband: Adjustable or fixed as required by application.

2.5 LIQUID-PRESSURE TRANSMITTERS

A. Liquid-Pressure Differential Transmitter:

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

2. Performance:
   a. Range: Approximately 2 times set point.
   b. Span: Adjustable plus or minus one milliamp, noninteractive.
   c. Accuracy: Within 0.25 percent of full scale.
   d. Pressure: Maximum operating pressure 2.5 times range.
   e. Temperature Limits: Zero to 175 deg F.
   f. Compensate Temperature Limits: 30 to 150 deg F.
   g. Thermal Effects: 0.02 percent of full scale per degree F.
   h. Response Time: 30 to 50 ms.
   i. Shock and vibration shall not harm the transmitter.
3. Analog Output Current Signal:
   a. Two-wire, 4- to 20-mA dc current source.
   b. Signal capable of operating into 1000-ohm load.

4. Operator Interface:
   a. Zero and span adjustments located behind cover.
   b. Bleed screws on side of body, two screws on low-pressure side, and one screw on high-pressure side, for air in line and pressure cavity.

5. Construction:
   a. Aluminum and stainless-steel enclosure with removable cover.
   b. Wetted parts of transmitter constructed of 17-4 PH or 300 Series stainless steel.
   c. Threaded, NPS 1/4 process connections on side of instrument enclosure.
   d. Knock out for 1/2-inch nominal conduit connection on side of instrument enclosure.
   e. Screw terminal block for wire connections.
   f. NEMA 250, Type 4X.
   g. Mounting Bracket: Appropriate for installation.

6. Three-valve manifold. Construct manifold of brass, bronze, or stainless steel. Manifold shall have threaded, NPS 1/4 process connections.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Install products level, plumb, parallel, and perpendicular with building construction.

B. Properly support instruments, tubing, piping wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement, sway, or a break in attachment when subjected to a seismic force.

C. Provide ceiling, floor, roof, wall openings, and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

D. Fastening Hardware:
   1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
   2. Tighten bolts and nuts firmly and uniformly. Do not to overstress threads by using excessive force or oversized wrenches.
   3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

E. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

F. Corrosive Environments:
1. Use products that are suitable for environment to which they are subjected.
2. If possible, avoid or limit use of materials in corrosive environments.
3. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
4. Where instruments are located in a corrosive environment and are not corrosive resistant from the manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.2 ELECTRICAL POWER

A. Furnish and install electrical power to products requiring electrical connections.
B. Furnish and install circuit breakers. Comply with requirements in Section 26 28 16 "Enclosed Switches and Circuit Breakers."
C. Furnish and install power wiring. Comply with requirements in Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."
D. Furnish and install raceways. Comply with requirements in Section 26 05 33 "Raceways and Boxes for Electrical Systems."

3.3 PRESSURE INSTRUMENT INSTALLATION

A. Mounting Location:

1. Rough-in: Outline instrument-mounting locations before setting instruments and routing, cable, wiring, tubing, and conduit to final location.
2. Install switches and transmitters for air and liquid pressure associated with individual air-handling units and associated connected ductwork and piping near air-handlings units co-located in air-handling unit system control panel, to provide service personnel a single and convenient location for inspection and service.
3. Install liquid and steam pressure switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
4. Install air-pressure switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
5. Mount switches and transmitters not required to be mounted within system control panels on walls, floor-supported freestanding pipe stands, or floor-supported structural support frames. Use manufacturer mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.
6. Install instruments (except pressure gages) in steam, liquid, and liquid-sealed piped services below their process connection point. Slope tubing down to instrument with a slope of 2 percent.
7. Install instruments in dry gas and noncondensable vapor piped services above their process connection point. Slope process connection lines up to instrument with a minimum slope of 2 percent.

B. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static pressure class and leakage and seal classes indicated using neoprene gaskets or grommets.

C. Duct Pressure Sensors:
1. Install sensors using manufacturer's recommended upstream and downstream distances.
2. Unless indicated on Drawings, locate sensors approximately 67 percent of distance of longest hydraulic run. Location of sensors shall be submitted and approved before installation.
3. Install mounting hardware and gaskets to make sensor installation airtight.
4. Route tubing from the sensor to transmitter.
5. Use compression fittings at terminations.
6. Install sensor in accordance with manufacturer's instructions.
7. Support sensor to withstand maximum air velocity, turbulence, and vibration encountered to prevent instrument failure.

D. Outdoor Pressure Sensors:

1. Install roof-mounted sensor in least-noticeable location and as far away from exterior walls as possible.
2. Locate wall-mounted sensor in an inconspicuous location.
3. Submit sensor location for approval before installation.
4. Verify signal from sensor is stable and consistent to all connected transmitters. Modify installation to achieve proper signal.
5. Route outdoor signal pipe full size of sensor connection to transmitters. Install branch connection of size required to match to transmitter.
6. Install sensor signal pipe with dirt leg and drain valve below roof penetration.
7. Insulate signal pipe with flexible elastomeric insulation as required to prevent condensation.
8. Connect roof-mounted signal pipe exposed to outdoors to building grounding system.

E. Air-Pressure Differential Switches:

1. Install air-pressure sensor in system for each switch connection. Install sensor in an accessible location for inspection and replacement.
2. A single sensor may be used to share a common signal to multiple pressure instruments.
3. Install access door in duct and equipment to access sensors that cannot be inspected and replaced from outside.
4. Route NPS 3/8 tubing from sensor to switch connection.
5. Do not mount switches on rotating equipment.
6. Install switches in a location free from vibration, heat, moisture, or adverse effects, which could damage the switch and hinder accurate operation.
7. Install switches in an easily accessible location serviceable from floor.
8. Install switches adjacent to system control panel if within 50 feet; otherwise, locate switch in vicinity of system connection.

F. Liquid-Pressure Differential Switches:

1. Where process connections are located in mechanical equipment room, install switch in convenient and accessible location near system control panel.
2. Where process connections are installed outside mechanical rooms, route processing tubing to mechanical room housing system control panel and locate switch near system control panel.
3. Where multiple switches serving same system are installed in same room, install switches by system to provide service personnel a single and convenient location for inspection and service.
4. System process tubing connection shall be full size of switch connection, but not less than NPS 1/2. Install stainless-steel bushing if required to mate switch to system connection.
5. Connect process tubing from point of system connection and extend to switch.
6. Install isolation valves in process tubing as close to system connection as practical.
7. Install dirt leg and drain valve at each switch connection.
8. Do not mount switches on rotating equipment.
9. Install switches in a location free from vibration, heat, moisture, or adverse effects, which could damage the switch and hinder accurate operation.
10. Install switches in an easily accessible location serviceable from floor.

G. Liquid-Pressure Transmitters:

1. Where process connections are installed in mechanical equipment room, install transmitter in convenient and accessible location near system control panel.
2. Where process connections are installed outside mechanical rooms, route processing tubing to mechanical room housing system control panel and locate transmitter near system control panel.
3. Where multiple transmitters serving same system are installed in same room, install transmitters by system to provide service personnel a single and convenient location for inspection and service.
4. System process tubing connection shall be full size of switch connection, but not less than NPS 1/2. Install stainless-steel bushing if required to mate switch to system connection.
5. Connect process tubing from point of system connection and extend to transmitter.
6. Install isolation valves in process tubing as close to system connection as practical.
7. Install dirt leg and drain valve at each transmitter connection.
8. Do not mount transmitters on equipment.
9. Install in a location free from vibration, heat, moisture, or adverse effects, which could damage and hinder accurate operation.

3.4 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

B. Install engraved phenolic nameplate with instrument identification[ and on face of ceiling directly below instruments concealed above ceilings].

3.5 CHECKOUT PROCEDURES

A. Check out installed products before continuity tests, leak tests, and calibration.
B. Check instruments for proper location and accessibility.
C. Check instruments for proper installation with respect to direction of flow, elevation, orientation, insertion depth, or other applicable considerations that impact performance.

3.6 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain instrumentation and control devices.
B. Coordinate pressure instrument demonstration video with operation and maintenance manuals and classroom instruction for use by Owner in operating, maintaining, and troubleshooting.
C. Record videos on DVD disks.
D. Owner shall have right to make additional copies of video for internal use without paying royalties.
END OF SECTION 23 09 23.23
SECTION 23 09 23.24 - SPEED INSTRUMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes speed switches for direct-digital controls for HVAC.

B. Related Requirements:
   1. Section 23 09 23 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.
   2. Section 23 09 93 "Sequence of Operations for HVAC Controls" for requirements that relate to Section 23 09 23.24.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:
   1. Include plans, elevations, sections, and mounting details.
   2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   3. Include diagrams for power, signal, and control wiring.
   4. Include number-coded identification system for unique identification of wiring.

1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 ROTATIONAL SPEED SWITCHES

A. Rotational Speed Switch (Non-Contact Type):

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

   2. Description:
      a. Speed switch, sensor, and electronics housed in enclosure.
      b. Shaft-end-mounted disc, or split collar wrap generates an alternating magnetic field sensed by the switch.
c. Dust, dirt, and grease proof.
d. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for hazardous environments Class I, Group D; Class II, Groups E, F, and G; and Class III.

3. Performance:
   a. Field-Adjustable Range: 100 to 5000 rpm.
   b. Temperature Limits: Minus 40 to 140 deg F.
   c. Electrical Rating: 5 A at 115-V ac.
   d. Switch Type: SPDT.
   e. Gap Distance: Approximately 0.375 inch.


5. Enclosure Construction:
   a. Cast aluminum.
   b. Removable cover.
   c. NEMA 250, Type 4X.
   d. Electrical Connection: Wiring, 12 inches long, furnished with switch.
   e. Conduit Connection: 1-inch trade size.

6. Disc, Guard, and Mounting Bracket Construction:
   a. Magnetic Disc: Nylon or PVC.
   b. Disc Guard: Stainless steel.
   c. Mounting Bracket: Aluminum with stainless-steel shaft.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Install products level, plumb, parallel, and perpendicular with building construction.

B. Properly support speed-switch wiring and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to a seismic force.

C. Fastening Hardware:
   1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
   2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
   3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

D. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

E. Corrosive Environments:
   1. Use products that are suitable for environment to which they are subjected.
2. If possible, avoid or limit use of materials in corrosive environments.

3. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.

4. Where instruments are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.2 ELECTRIC POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 26 28 16 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 26 05 33 "Raceways and Boxes for Electrical Systems."

3.3 SPEED-SWITCH INSTALLATIONS

A. Use manufacturer's mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.

B. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static-pressure class and leakage and seal classes indicated using neoprene gaskets or grommets.

3.4 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

B. Install engraved phenolic nameplate with instrument identification[ and on face of ceiling directly below instruments concealed above ceilings].

END OF SECTION 23 09 23.24
PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Air temperature sensors.
   2. Air temperature switches.
   3. Air temperature RTD transmitters.
   4. Liquid and steam temperature sensors.
   5. High-end, commercial-grade, liquid and steam temperature sensors.
   7. High-end, commercial-grade, liquid and steam temperature transmitters.

B. Related Requirements:
   1. Section 23 09 23 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.
   2. Section 23 09 93 "Sequence of Operations for HVAC Controls" for requirements that relate to Section 23 09 23.27.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:
   1. Include plans, elevations, sections, and mounting details.
   2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   3. Include diagrams for power, signal, and control wiring.
   4. Include number-coded identification system for unique identification of wiring, cable, and tubing ends.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Environmental Conditions:
1. Instruments shall operate without performance degradation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified and encountered for installed location.
   a. If instrument alone cannot meet requirement, install instrument in a protective enclosure that is isolated and protected from conditions impacting performance. Enclosure shall be internally insulated, electrically heated and cooled, filtered, and ventilated as required by instrument and application.

2. Instruments and accessories shall be protected with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Instruments not available with integral enclosures complying with requirements indicated shall be housed in protective secondary enclosures. Instrument's installed location shall dictate following NEMA 250 enclosure requirements:
   a. Outdoors, Protected: Type 3.
   b. Outdoors, Unprotected: Type 4X.
   c. Indoors, Heated with Filtered Ventilation: Type 2.
   d. Indoors, Heated with Non-Filtered Ventilation: Type 12.
   e. Indoors, Heated and Air Conditioned: Type 1.
   f. Mechanical Equipment Rooms:
      1) Mechanical Rooms: Type 4.
      2) Air-Moving Equipment Rooms: Type 12.
   g. Localized Areas Exposed to Washdown: Type 4.
   h. Within Duct Systems and Air-Moving Equipment Not Exposed to Possible Condensation: Type 2.
   i. Within Duct Systems and Air-Moving Equipment Exposed to Possible Condensation: Type 4.

2.2 AIR TEMPERATURE SENSORS

A. Platinum RTDs: Common Requirements:
   1. 100 or 1000 ohms at zero deg C and a temperature coefficient of 0.00385 ohm/ohm/deg C.
   2. Two-wire, PTFE-insulated, 22-gage stranded copper leads.
   3. Performance Characteristics:
      a. Range: Minus 50 to 275 deg F.
      b. Interchangeable Accuracy: At 32 deg F within 0.5 deg F.
      c. Repeatability: Within 0.5 deg F.
   4. Transmitter Requirements:
      a. Transmitter required for each 100-ohm RTD.
      b. Transmitter optional for 1000-ohm RTD, contingent on compliance with end-to-end control accuracy.

B. Platinum RTD, Single-Point Air Temperature Duct Sensors:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Minco

2. 100 or 1000 ohms.
3. Temperature Range: Minus 50 to 275 deg F
5. Length: As required by application to achieve tip at midpoint of air tunnel, up to 18 inches.
6. Enclosure: Junction box with removable cover; NEMA 250, Type 1 for indoor applications and Type 4 for outdoor applications.
7. Gasket for attachment to duct or equipment to seal penetration airtight.
8. Conduit Connection: 1/2-inch

C. Platinum RTD, Air Temperature Averaging Sensors:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Minco

2. 100 or 1000 ohms.
3. Temperature Range: Minus 50 to 275 deg F
4. Multiple sensors to provide average temperature across entire length of sensor.
5. Rigid probe of aluminum, brass, copper, or stainless-steel sheath.
6. Flexible probe of aluminum, brass, copper, or stainless-steel sheath and formable to a 4-inch radius.
7. Length: As required by application to cover entire cross section of air tunnel.
8. Enclosure: Junction box with removable cover; NEMA 250, Type 1 for indoor applications and Type 4 for outdoor applications.
9. Gasket for attachment to duct or equipment to seal penetration airtight.
10. Conduit Connection: 1/2-inch

D. Platinum RTD Outdoor Air Temperature Sensors:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Minco

2. 100 or 1000 ohms.
3. Temperature Range: Minus 50 to 275 deg F
6. Enclosure: NEMA 250, Type 4 or 4X junction box or combination conduit and outlet box with removable cover and gasket.
7. Conduit Connection: 1/2-inch trade size.

E. Platinum RTD Space Air Temperature Sensors:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Minco
2.  100 or 1000 ohms.
3.  Temperature Range: Minus 50 to 212 deg F
4.  Sensor assembly shall include a temperature sensing element mounted under a flush, brushed aluminum cover.
5.  Provide a mounting plate that is compatible with the surface shape that it is mounted to and electrical box used.
6.  Concealed wiring connection.

F. Thermal Resistors (Thermistors): Common Requirements:

1.  10,000 ohms at 25 deg C and a temperature coefficient of 23.5 ohms/ohm/deg C.
2.  Two-wire, PTFE-insulated, 22-gage stranded copper leads.
3.  Performance Characteristics:
   a.  Range: Minus 50 to 275 deg F.
   b.  Interchangeable Accuracy: At 77 deg F within 0.5 deg F.
   c.  Repeatability: Within 0.5 deg F.
   d.  Drift: Within 0.5 deg F over 10 years.
   e.  Self-Heating: Negligible.

4.  Transmitter optional, contingent on compliance with end-to-end control accuracy.

G. Thermistor, Single-Point Duct Air Temperature Sensors:

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

2.  Temperature Range: Minus 50 to 275 deg F
4.  Length: As required by application to achieve tip at midpoint of air tunnel, up to 18 inches.
5.  Enclosure: Junction box with removable cover; NEMA 250, Type 1 for indoor applications and Type 4 for outdoor applications.
6.  Gasket for attachment to duct or equipment to seal penetration airtight.
7.  Conduit Connection: 1/2-inch trade size.

H. Thermistor Averaging Air Temperature Sensors:

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

2.  Temperature Range: Minus 50 to 275 deg F
3.  Multiple sensors to provide average temperature across entire length of sensor.
4.  Rigid probe of aluminum, brass, copper, or stainless-steel sheath.
5.  Flexible probe of aluminum, brass, copper, or stainless-steel sheath and formable to a 4-inch radius.
6.  Length: As required by application to cover entire cross section of air tunnel.
7.  Enclosure: Junction box with removable cover; NEMA 250, Type 1 for indoor applications and Type 4 for outdoor applications.
8.  Gasket for attachment to duct or equipment to seal penetration airtight.
I. Thermistor Outdoor Air Temperature Sensors:

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

2. Temperature Range: Minus 50 to 275 deg F
5. Enclosure: NEMA 250, Type 4 or 4X junction box or combination conduit and outlet box with removable cover and gasket.

J. Thermistor Space Air Temperature Sensors:

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

2. Temperature Range: Minus 50 to 212 deg F
3. Sensor assembly shall include a temperature sensing element mounted under a flush, brushed aluminum cover.
4. Provide a mounting plate that is compatible with the surface shape that it is mounted to and electrical box used.
5. Concealed wiring connection.

K. Space Air Temperature Sensors for Use with DDC Controllers Controlling Terminal Units:

1. 100- or 1000-ohm platinum RTD or thermistor.
2. Thermistor:
   a. Pre-aged, burned in, and coated with glass; inserted in a metal sleeve; and entire unit encased in epoxy.
   b. Thermistor drift shall be less than plus or minus 0.5 deg F over 10 years.

3. Temperature Transmitter Requirements:
   a. Mating transmitter required with each 100-ohm RTD.
   b. Mating transmitters optional for 1000-ohm RTD and thermistor, contingent on compliance with end-to-end control accuracy.

4. Provide digital display of sensed temperature.
5. Provide sensor with local control.
   a. Local override to turn HVAC on.
   b. Local adjustment of temperature set point.
   c. Both features shall be capable of manual override through control system operator.

2.3 AIR TEMPERATURE SWITCHES

A. Thermostat and Switch for Low Temperature Control in Duct Applications:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Honeywell International
   b. Siemens Building Technology

2. Description:
   a. Two-position control.
   b. Field-adjustable set point.
   d. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

3. Performance:
   a. Operating Temperature Range: 15 to 55 deg F.
   b. Temperature Differential: 5 deg F, non-adjustable and additive.
   c. Enclosure Ambient Temperature: Minus 20 to 140 deg F.
   d. Sensing Element Maximum Temperature: 250 deg F.
   e. Voltage: 120-V ac.
   f. Current: 16 FLA.
   g. Switch Type: Two SPDT snap switches operate on coldest 12-inch section along element length.

4. Construction:
   a. Vapor-Filled Sensing Element: Nominal 20 feet long.
   b. Dual Temperature Scale: Fahrenheit and Celsius visible on face.
   c. Set-Point Adjustment: Screw.
   d. Enclosure: Painted metal, NEMA 250, Type 1.
   e. Electrical Connections: Screw terminals.
   f. Conduit Connection: 1/2-inch trade size.

B. Thermostat and Switch for High Temperature Control in Duct Applications:

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

2. Source Limitations: Obtain temperature-measuring sensors and transmitters and airflow from single manufacturer.

3. Description:
   a. Two-position control.
   b. Field-adjustable set point.
   d. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

4. Performance:
   a. Temperature Range: 100 to 160 deg F.
b. Temperature Differential: 5 deg F.
c. Ambient Temperature: Zero to 260 deg F.
d. Voltage: 120-V ac.
e. Current: 16 FLA.
f. Switch Type: SPDT snap switch.

5. Construction:
   b. Enclosure: Metal, NEMA 250, Type 1.
   c. Electrical Connections: Screw terminals.
   d. Conduit Connection: 1/2-inch trade size.

2.4 AIR TEMPERATURE RTD TRANSMTTERS

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

B. Source Limitations: Obtain temperature-measuring sensors and transmitters and airflow from single manufacturer.

C. House electronics in NEMA 250 enclosure.
   1. Duct: Type 3.
   2. Outdoor: Type 4 or Type 4X.
   3. Space: Type 1.

D. Conduit Connection: 1/2-inch

E. Functional Characteristics:
   1. Input:
      a. 100-ohm platinum RTD temperature coefficient of 0.00385 ohm/ohm/deg C, two-wire sensors.
      b. 1000-ohm platinum RTD temperature coefficient of 0.00385 ohm/ohm/deg C, two-wire sensors.

2. Span (Adjustable):
   a. Space: 40 to 90 deg F.
   b. Supply Air Cooling and Heating: 40 to 120 deg F.
   c. Supply Air Cooling Only: 40 to 90 deg F.
   d. Supply Air Heating Only: 40 to 120 deg F.
   e. Exhaust Air: 50 to 100 deg F.
   f. Return Air: 50 to 100 deg F.
   g. Mixed Air: Minus 40 to 140 deg F.
   h. Outdoor: Minus 40 to 140 deg F.

3. Output: 4- to 20-mA dc, linear with temperature; RFI insensitive; minimum drive load of 600 ohms at 24-V dc.
4. Zero and span field adjustments, plus or minus 5 percent of span. Minimum span of 50 deg F.
5. Match sensor with temperature transmitter and factory calibrate together.

F. Performance Characteristics:

1. Calibration Accuracy: Within 0.1 percent of the span.
2. Stability: Within 0.2 percent of the span for at least 6 months.
3. Combined Accuracy: Within 0.5 percent.

2.5 LIQUID AND STEAM TEMPERATURE SENSORS, COMMERCIAL GRADE

A. RTD:

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

2. Description:
   a. Platinum with a value of 100 or 1000 ohms at zero deg C and a temperature coefficient of 0.00385 ohm/ohm/deg C.
   b. Encase RTD in a stainless-steel sheath with a 0.25-inch OD.
   c. Sensor Length: 4, 6, or 8 inches as required by application.
   d. Process Connection: Threaded, NPS 1/2
   e. Two-stranded copper lead wires.
   f. Powder-coated steel enclosure, NEMA 250, Type 4.
   g. Conduit Connection: 1/2-inch
   h. Performance Characteristics:

      1) Range: Minus 40 to 210 deg F.
      2) Interchangeable Accuracy: Within 0.54 deg F at 32 deg F.

B. Thermowells:

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

2. Stem: Straight or stepped shank formed from solid bar stock.
3. Material: Brass or stainless steel.
5. Sensor Connection: Threaded, NPS 1/2.
6. Bore: Sized to accommodate sensor with tight tolerance between sensor and well.
7. Furnish thermowells installed in insulated pipes and equipment with an extended neck.
8. Length: 4, 6, or 8 inches as required by application.
9. Thermowells furnished with heat-transfer compound to eliminate air gap between wall of sensor and thermowell and to reduce time constant.

2.6 LIQUID AND STEAM TEMPERATURE SENSORS, HIGH-END COMMERCIAL GRADE

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

2. Resistance temperature sensors shall comply with IEC 60751, Class B requirements.
3. Platinum with a value of 100 ohms at zero deg C and a temperature coefficient of 0.00385 ohm/ohm/deg C.
4. Encase RTD in a Type 316 stainless-steel sheath with a 0.25-inch OD.
5. Provide four-wire, PTFE-insulated, nickel-coated, 22-gage, stranded copper leads.
6. Provide spring-loaded RTDs for thermowell installations.
7. Performance Characteristics:
   a. Range: Minus 328 to 932 deg F.
   b. Interchangeable Accuracy: Within 0.54 deg F at 32 deg F.
   c. Stability: Within 0.05 percent maximum ice-point resistance shift after 1000 hours at 752 deg F.
   d. Hysteresis: Within 0.04 percent of range.
   e. Response Time: 62.8 percent of change in 4 seconds with water flowing across sensor at 3 fps.

B. Thermowells:

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

2. Stem: Straight or stepped shank formed from solid bar stock.
3. Material: Type 304 or Type 316 stainless steel.
4. Process Connection: Threaded, NPS 3/4
5. Sensor Connection: Threaded, NPS 1/2
6. Bore: Sized to accommodate sensor with tight tolerance between sensor and well.
7. Furnish thermowells installed in insulated pipes and equipment with an extended neck that extends beyond the face of the insulation covering.
8. Length: As required by application and pipe size.
9. Thermowells furnished with heat-transfer compound to eliminate air gap between wall of sensor and thermowell and to reduce time constant.

C. Connection Heads:

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

2. Housing: Low-copper cast-aluminum alloy, complying with NEMA 250, Type 4.
3. Terminals: Six or eight as required by sensor.
5. Sensor Connection: NPS 1/2.

D. Assembly: Sensor manufacturer shall furnish sensor, thermowell, and sensor connection head to provide a matched assembly.
2.7 LIQUID TEMPERATURE SWITCHES

A. Thermostat and Switch for Temperature Control in Pipe Applications:

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

2. Description:
   a. Two-position control.
   b. Field-adjustable set point.
   d. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

3. Performance:
   a. Operating Temperature Range: 65 to 200 deg F.
   b. Temperature Differential Deadband: 5 to 30 deg F, adjustable.
   c. Enclosure Ambient Temperature: 150 deg F.
   e. Voltage: 120-V ac.
   f. Current: 8 FLA.
   g. Switch Type: SPDT snap switch.

4. Construction:
   a. Vapor-Filled Immersion Element: Copper, nominal 3 inches long.
   b. Temperature Scale: Fahrenheit, visible on face.
   c. Set-Point Adjustment: Screw.
   d. Enclosure: Painted metal, NEMA 250, Type 1.
   e. Electrical Connections: Screw terminals.
   f. Conduit Connection: 3/4-inch.

2.8 LIQUID AND STEAM TEMPERATURE TRANSMITTERS, COMMERCIAL GRADE

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

1. Minco

B. House electronics in NEMA 250, Type 4 or Type 4X enclosure.

C. Enclosure Connection: 1/2-inch trade size.

D. Functional Characteristics:

1. Input: 100-ohm platinum RTD temperature coefficient of 0.00385 ohm/ohm/deg C, two- or three-wire sensors.
2. Default Span (Adjustable):
   a. Heat Pump Water: Zero to 120 deg F.
b. Heating Hot Water: 32 to 212 deg F.

3. Output: 4- to 20-mA dc, linear with temperature; RFI insensitive; minimum drive load of 600 ohms at 24-V dc.
4. Zero and span field adjustments, plus or minus 5 percent of span. Minimum span of 50 deg F.
5. Match sensor with temperature transmitter and factory calibrate together. Each matched sensor and transmitter set shall include factory calibration data traceable to NIST.

E. Performance Characteristics:

1. Calibration Accuracy: Within 0.1 percent of the span.
2. Stability: Within 0.2 percent of the span for at least 6 months.
3. Combined Accuracy: Within 0.5 percent.

PART 3 - EXECUTION

3.1 TEMPERATURE INSTRUMENT APPLICATIONS

A. Air Temperature Sensors:

1. Duct:, 100-ohm platinum RTD.
2. Outdoor:, 100-ohm platinum RTD.
3. Space:, 100-ohm platinum RTD.

B. Air Temperature Transmitters:

1. Duct:, Air temperature RTD transmitter.
2. Outdoor:, Air temperature RTD transmitter.
3. Space:, Air temperature RTD transmitter.

C. Liquid and Steam Temperature Sensors:

1. Steam and Heat Pump and Heating System:, Liquid and steam temperature sensor, commercial grade.

D. Liquid and Temperature Transmitters:

1. Liquid and steam temperature transmitter, commercial grade.

3.2 INSTALLATION, GENERAL

A. Install products level, plumb, parallel, and perpendicular with building construction.

B. Properly support instruments, tubing, piping, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to a seismic force.

C. Fastening Hardware:

1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

D. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

E. Corrosive Environments:
1. Use products that are suitable for environment to which they are subjected.
2. If possible, avoid or limit use of materials in corrosive environments.
3. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
4. Where instruments are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.3 ELECTRIC POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 26 28 16 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 26 05 33 "Raceways and Boxes for Electrical Systems."

3.4 TEMPERATURE INSTRUMENT INSTALLATIONS

A. Mounting Location:
1. Roughing In:
   a. Outline instrument mounting locations before setting instruments and routing cable, wiring, tubing, and conduit to final location.
   b. Provide independent inspection to confirm that proposed mounting locations comply with requirements indicated and approved submittals.
      1) Indicate dimensioned locations with mounting height for all surface-mounted products on Shop Drawings.
      2) Do not begin installation without submittal approval of mounting location.
   c. Complete installation rough-in only after confirmation by independent inspection is complete and approval of location is documented for review by Owner and Architect on request.
2. Install switches and transmitters for air and liquid temperature associated with individual air-handling units and associated connected ductwork and piping near air-handling units co-located in air-handling unit system control panel to provide service personnel a single and convenient location for inspection and service.

3. Install liquid and steam temperature switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.

4. Install air temperature switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.

5. Mount switches and transmitters on walls, floor-supported freestanding pipe stands, or floor-supported structural support frames. Use manufacturer's mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.

B. Special Mounting Requirements:

1. Protect products installed outdoors from solar radiation, building and wind effect with stand-offs and shields constructed of Type 316 stainless.

2. Temperature instruments having performance impacted by temperature of mounting substrate shall be isolated with an insulating barrier located between instrument and substrate to eliminate effect. Where instruments requiring insulation are located in finished space, conceal insulating barrier in a cover matching the instrument cover.

C. Mounting Height:

1. Mount temperature instruments in user-occupied space to match mounting height of light switches unless otherwise indicated on Drawings. Mounting height shall comply with codes and accessibility requirements.

2. Mount switches and transmitters located in mechanical equipment rooms and other similar space not subject to code or state and Federal accessibility requirements within a range of 42 to 72 inches above the adjacent floor, grade, or service catwalk or platform.

   a. Make every effort to mount at 60 inches.

D. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static-pressure class and leakage and seal classes indicated using neoprene gaskets or grommets.

E. Space Temperature Sensor Installation:

1. Conceal assembly in an electrical box of sufficient size to house sensor and transmitter, if provided.

2. Install electrical box with a faceplate to match sensor cover if sensor cover does not completely cover electrical box.

3. In finished areas, recess electrical box within wall.

4. In unfinished areas, electrical box may be surface mounted if electrical light switches are surface mounted. Use a cast-aluminum electric box for surface-mounted installations.

5. Align electrical box with other electrical devices such as visual alarms and light switches located in the vicinity to provide a neat and well-thought-out arrangement. Where possible, align in both horizontal and vertical axis.

F. Outdoor Air Temperature Sensor Installation:

1. Mount sensor in a discrete location facing north.

2. Protect installed sensor from solar radiation and other influences that could impact performance.

3. If required to have a transmitter, mount transmitter remote from sensor in an accessible and serviceable location indoors.
G. Single-Point Duct Temperature Sensor Installation:

1. Install single-point-type, duct-mounted, supply- and return-air temperature sensors. Install sensors in ducts with sensitive portion of the element installed in center of duct cross section and located to sense near average temperature. Do not exceed 24 inches in sensor length.
2. Install return-air sensor in location that senses return-air temperature without influence from outdoor or mixed air.
3. Rigidly support sensor to duct and seal penetration airtight.
4. If required to have transmitter, mount transmitter remote from sensor at accessible and serviceable location.

H. Averaging Duct Temperature Sensor Installation:

1. Install averaging-type air temperature sensor for temperature sensors located within air-handling units, similar equipment, and large ducts with air tunnel cross-sectional area of 20 sq. ft. and larger.
2. Install sensor length to maintain coverage over entire cross-sectional area. Install multiple sensors where required to maintain the minimum coverage.
3. Fasten and support sensor with manufacturer-furnished clips to keep sensor taut throughout entire length.
4. If required to have transmitter, mount transmitter in an accessible and serviceable location.

I. Low-Limit Air Temperature Switch Installation:

1. Install multiple low-limit switches to maintain coverage over entire cross-sectional area of air tunnel.
2. Fasten and support sensing element with manufacturer-furnished clips to keep element taut throughout entire length.
3. Mount switches outside of airstream at a location and mounting height to provide easy access for switch set-point adjustment and manual reset.
4. Install on entering side of cooling coil unless otherwise indicated on Drawings.

J. Liquid Temperature Sensor Installation:

1. Assembly shall include sensor, thermowell and connection head.
2. For pipe NPS 4 and larger, install sensor and thermowell length to extend into pipe between 50 to 75 percent of pipe cross section.
3. For pipe smaller than NPS 4:
   a. Install reducers to increase pipe size to NPS 4 at point of thermowell installation.
   b. For pipe sizes NPS 2-1/2 and NPS 3, thermowell and sensor may be installed at pipe elbow or tee to achieve manufacturer-recommended immersion depth in lieu of increasing pipe size.
   c. Minimum insertion depth shall be 2-1/2 inches.
4. Install matching thermowell.
5. Fill thermowell with heat-transfer fluid before inserting sensor.
6. Tip of spring-loaded sensors shall contact inside of thermowell.
7. For insulated piping, install thermowells with extension neck to extend beyond face of insulation.
8. Install thermowell in top dead center of horizontal pipe positioned in an accessible location to allow for inspection and replacement. If top dead center location is not possible due to field constraints, install thermowell at location along top half of pipe.
9. For applications with transmitters, mount transmitter remote from sensor in an accessible and serviceable location from floor service platform or catwalk.
3.5 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

B. Install engraved phenolic nameplate with instrument identification[ and on face of ceiling directly below instruments concealed above ceilings].

3.6 CLEANING

A. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed interior and exterior surfaces.

B. Wash and shine glazing.

C. Polish glossy surfaces to a clean shine.

3.7 CHECK-OUT PROCEDURES

A. Check installed products before continuity tests, leak tests, and calibration.

B. Check temperature instruments for proper location and accessibility.

C. Verify sensing element type and proper material.

D. Verify location and length.

E. Verify that wiring is correct and secure.

3.8 FIELD QUALITY CONTROL

A. Perform the following tests and inspections[ with the assistance of a factory-authorized service representative]:

1. Perform according to manufacturer's written instruction.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Prepare test and inspection reports.

3.9 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.
3.10 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain temperature instruments.

END OF SECTION 23 09 23.27
SECTION 23 09 23.43 - WEATHER STATIONS

PART 1 - GENERAL

1.1 SUMMARY
   A. Section includes weather stations connected to direct-digital controls for HVAC.
   B. Related Requirements:
      1. Section 23 09 23 "Direct-Digital Control System for HVAC" for control equipment and software,
         relays, electrical power devices, uninterruptible power supply units, wire, and cable.
      2. Section 23 09 93 "Sequence of Operations for HVAC Controls" for requirements that relate to
         Section 23 09 23.43.

1.2 ACTION SUBMITTALS
   A. Product Data: For each type of product.
   B. Shop Drawings:
      1. Include plans, elevations, sections, and mounting details.
      2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances,
         method of field assembly, components, and location and size of each field connection.
      3. Include diagrams for power, signal, and control wiring.
      4. Include number-coded identification system for unique identification of wiring, cable, and tubing
         ends.

1.3 INFORMATIONAL SUBMITTALS
   A. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS
   A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 WEATHER STATION
   A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1. WeatherHawk
   B. Description:
1. Weather station shall measure and record wind speed and direction, air temperature and relative humidity, barometric pressure, solar radiation, and rain.

2. Design weather station for applications with minimal visual impact, high reliability, and a long interval between routine servicing.

3. Weather station shall use solid-state sensors with no moving parts.

4. Weather station shall not be impaired by heavy snowfall or freezing conditions that produce rime ice. Provide a thermostatically controlled heater element in the sensor head that keeps the wind sensor elements and the precipitation sensor surface free of snow and ice to minus 62 deg F.

5. Weather station shall directly connect to host device, or wirelessly connect to a host device through a fully integrated, industrial-grade, 916-MHz spread spectrum radio-frequency communications technology. Where required by application, replace 916-MHz radio-frequency components with 922-MHz and 2.4-GHz radio-frequency components to comply with local, regional, and national radio-frequency licensing requirements.

6. RS-232 serial data I/O shall be located on the bottom of the weather station and used as a second serial communications port, for programming and testing the system, or for direct data downloads using a personal computer or personal digital assistant.

7. Weather station shall be provided with a mounting system supplied by weather station manufacturer that is suitable for the installation.

C. Sensor Technology:

1. Wind speed and direction shall use acoustic techniques. Sensor shall consist of three equally spaced ultrasonic transducers in a horizontal plane. Values of any two array paths shall enable computation of both wind speed and direction, and a signal processing technique shall enable the measurement to be calculated using the two array paths of the best quality.

2. Rain shall be measured using a stainless-steel piezometric impact surface that counts the raindrops and measures their acoustic signature, integrating that information to provide a near-real-time value for rainfall amount and rate.

3. Barometric pressure, relative humidity, air temperature, and solar radiation measurements shall be made by scientific grade sensors.

4. Air-temperature and relative-humidity sensors shall be combined in an integrated, user-replaceable unit that requires no calibration.
   a. Relative humidity sensor shall be a thin-polymer, capacitive sensor.
   b. Air-temperature sensor shall be a capacitive ceramic sensor.

5. Barometric pressure shall be measured with a capacitive silicon, temperature-corrected, strain gage.

6. Solar radiation shall be measured by a silicon pyranometer with a cut filter limiting the spectral exposure to the 300- to 1100-nm wavelength.

D. Performance:

1. Air Temperature:
   a. Range: Minus 60 to 140 deg F.
   b. Accuracy: Within 0.9 deg F.
   c. Resolution: 0.1 deg F.

2. Relative Humidity:
   a. Range: Zero to 100 percent.
   b. Accuracy: Within 3 percent over the range of zero to 90 percent and within 5 percent between 90 to 100 percent.
   c. Resolution: 0.1 percent.
3. Barometric Pressure:
   a. Range: 17.72- to 32.48-in. Hg.
   b. Accuracy: 0.015-in. Hg between 32 to 86 deg F.
   c. Resolution: 0.03-in. Hg between minus 60 to 140 deg F.

4. Solar Radiation:
   a. Spectral Range: 300 to 1100 nm.
   b. Reproducibility: Within 2 percent.
   c. Output: 0.2 mV per watts per square meters.
   d. Range: Zero to 1000 W per square meters.
   e. Temperature Range: Minus 40 to 130 deg F.

5. Rain:
   a. Collecting Area: 9.3 sq. in.
   b. Range: Zero to 7.87 inches per hour.
   c. Accuracy: Within 5 percent.
   d. Resolution: 0.001 inch.

6. Wind Direction:
   a. Azimuth: Zero to 360 degrees.
   b. Response Time: 250 ms.
   c. Accuracy: Within 2 degrees.
   d. Resolution: 1 degree.

7. Wind Speed:
   a. Range: Zero to 134 mph.
   b. Response Time: 0.25 second.
   c. Accuracy: Greater of 0.67 mph or 2 percent.
   d. Resolution: 0.22 mph.

8. Data Storage: 60 days of hourly data.

E. Output Signals:
   1. RS-232 or RS-485 serial interface directly from weather station to host.
   2. In applications that cannot accept a serial signal, provide a serial-to-analog converter.
   3. Serial-to-Analog Converter:
      a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
         1) Minco
      b. Serial converter designed to add analog outputs for measuring instruments that have only serial output.
      c. Configure to give analog outputs from all measuring sensors and calculated parameters.
      d. Each converter shall have four analog outputs with a 4- to 20-mA signal.
      e. Provide multiple converters for applications requiring more points.
      f. Converter requires a 24-V dc power supply.
F. Communication Interface:
   1. Weatherproof serial cables shall be used to connect the RS-232 I/O on the weather station. Cables shall use nickel-plated brass DB-9 connectors for corrosion resistance and include a Sanoprene jacket suitable for both high-ultraviolet and direct-burial environments.
   2. An RF4xx spread spectrum radio-frequency transceiver shall be provided with every wireless weather station.

G. Unit shall be provided with a 120-V ac, 60-Hz power supply, a serial cable, and an antenna.

H. Software:
   1. Data Transfer Protocols, Software, and Data Interface Hardware: Weather stations that communicate using a proprietary protocol shall be provided with a software development kit to enable a qualified software developer in development of software drivers for third-party devices or software.
   2. Manufacturer shall submit description and pricing information of software application offerings for weather station management, data acquisition and logging, report generation, and data display for review and consideration.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install products level, plumb, parallel, and perpendicular with building construction.

B. Properly support weather station, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to forces that are consistent with building code structural design requirements.

C. Fastening Hardware:
   1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
   2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
   3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

D. Corrosive Environments:
   1. Use products that are suitable for environment to which they are subjected.
   2. If possible, avoid or limit use of materials in corrosive environments.
   3. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
   4. Where components are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.
3.2 ELECTRIC POWER
   A. Furnish and install electrical power to products requiring electrical connections.
   B. Furnish and install circuit breakers. Comply with requirements in Section 26 28 16 "Enclosed Switches and Circuit Breakers."
   C. Furnish and install power wiring. Comply with requirements in Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."
   D. Furnish and install raceways. Comply with requirements in Section 26 05 33 "Raceways and Boxes for Electrical Systems."

3.3 IDENTIFICATION
   A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."
   B. Install engraved phenolic nameplate with instrument identification.

3.4 FIELD QUALITY CONTROL
   A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
   B. Prepare test and inspection reports.

3.5 DEMONSTRATION
   A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain weather stations.

END OF SECTION 23 09 23.43
SECTION 23 09 93.11 - SEQUENCE OF OPERATIONS FOR HVAC DDC

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes control sequences for DDC for HVAC systems, subsystems, and equipment.

B. Related Requirements:
   1. Section 230923 "DDC Systems for HVAC" for control equipment.
   2. Section 23 09 23.11 Control Valves
   3. Section 23 09 23.12 Control Dampers
   4. Section 23 09 23.13 ENERGY METERS
   5. Section 23 09 23.14 FLOW INSTRUMENTS
   6. Section 23 09 23.16 GAS INSTRUMENTS
   7. Section 23 09 23.17 LEVEL INSTRUMENTS
   8. Section 23 09 23.22 POSITION INSTRUMENTS
   9. Section 23 09 23.23 PRESSURE INSTRUMENTS
  10. Section 23 09 23.24 SPEED INSTRUMENTS
  11. Section 23 09 23.27 TEMPERATURE INSTRUMENTS
  12. Section 23 09 23.43 WEATHER STATIONS

1.2 SEQUENCE GENERAL NOTES:

A. All major set points and parameters shall be displayed and adjustable by the operator from the graphics. Minor set points and parameters can reside in the points folder or not integrated. Ultimate authority will be MSU staff. Any points requested, shall be provided at the graphic level to meet their requests.

B. All outputs, variable set points, and system modes shall be override commandable from the graphics. Ultimate authority will be MSU staff. Any points requested, shall be provided at the graphic level to meet their requests.

C. All overrides shall be prominently displayed with a purple background to alert the operator of an override. An override report shall list all point in override. Report shall be exportable to PDF or CVS format.

D. All points that move shall be trended with a hyperlink from the graphics

E. All binary points shall retain runtime and cycles. Runtimes shall be displayed on graphics. Cycle times shall be displayed on graphics when applicable (upon request by MSU).

F. The following sequences state the general intent of system operation. It should be inferred that differentials, deadbands, delays, loop tuning shall be added by the system programmer to allow for optimally smooth transitions and prevention of unnecessary cycling of modes and or systems. Any observed adverse anomalies shall be addressed by the system programmer with no additional cost to the project.

G. Default Valve position:
1. All heat pump control valves shall fail to the factory default position as determined by the manufacturer.
2. All heating control valves shall fail open if exposed to outside air or potential to freezing conditions.
3. All Steam Valves serving hot water heat exchangers shall fail closed.
4. Window actuators are not spring return. They will fail in their last commanded position.

H. T-stats/Room Sensors: provide with occupancy override button in all non-public areas. Vandal proof sensor, locking guards or sensors with user features locked out shall be provided in public areas. Submit a room sensor schedule with submittal. MSU/ME shall have ultimate final say as to sensor styles without additional cost.

I. All controllers serving primary equipment, atrium smoke controls, network managers, and routers shall be served by emergency power circuits.

1.3 ATRIUM SMOKE CONTROL MODE

A. All functions in this mode shall be provided by a DDC controller that is UL 864 listed for smoke control. Provide an independent listed controller or a separate control system (if necessary), interlocked to the Firefighters Smoke Control Station provided by the electrical contractor (relays to be mounted to the smoke control temperature control panel located in mechanical penthouse). All routines shall be inherent to the local listed controller and shall not rely on parts of the systems that are not listed. Follow the explicit requirements of NFPA 92B and the International Building Code Chapter 9.

B. The fire alarm system shall provide dry contact signals to the DDC system for invoking smoke control response. The signals shall be Atrium Fire Smoke Event, Firefighter Manual Active command, Firefighter Manual Inactive command. The DDC System shall respond to the various smoke control modes upon request from any of the signals. These smoke control signals shall take priority over all other automatic routines and operator commands from any other man machine interface (MMI). Wire as necessary to fire alarm control panel for signals required for smoke sensing. Provide necessary relays, etc for DDC system activation.

C. When Atrium Fire Smoke Event or Firefighter Manual Active signal is detected the following responses should occur:
   1. DDC system shall open operable windows indicated as SC (Smoke Control) windows on mechanical drawings.
   2. DDC system shall provide signal to smoke control doors to open. Coordinate signal type and location with door hardware supplier.
   3. DDC system shall start smoke fans EF-S1, EF-S2, EF-S3. T.C. Contractor to enable fan and program ramp time on VFD’s as follows: from 0 to 100% over a 45 second period (adj.)
   4. The Fire Alarm system shall provide relay to mechanical rooms as required for TC to hardware shut down for all air handling systems including first floor shop heat pumps, AHU-1, ECON-1, DOAS-1, all other exhaust systems, etc. All other heat pumps shall be shut down via software.

D. Firefighter Manual Modes:
   1. When the Firefighter Manual Inactive signal is received from the fire alarm system the DDC shall place all smoke control devices to an inactive state.
   2. When no command is received from the Atrium Fire Smoke Event, or the Firefighter Manual Active, or the Firefighter Manual Inactive signals; the system shall revert to normal operations as outline below. Reference Section 283111 – Digital, Addressable Fire Alarm System for further information.
1.4 RELIEF FAN MODE (EF-S1, EF-S2, EF-S3)

A. When the building pressure exceeds 0.02" wc., open the motorized dampers on the inlet of EF-S1, EF-S2 and EF-S3 in sequence – dampers shall be 2 position. Provide damper position switch. Provide position indication for damper on the graphics.

B. When the building pressure exceeds 0.03" wc. and the smoke exhaust fan inlet motorized dampers are proven open, activate lead smoke exhaust fan (operate fans in lead lag manner, alternating lead status every week). Operate fan at minimum VFD speed and slowly increase as needed to maintain atrium space pressure set point of 0.025" wc. As needed, cycle on remaining fans, and ramp together.

C. Night Flush Cycle:

   A night flush cycle shall be implemented to precool the building when conditions permit. The following conditions must be met in order to initiate the night purge sequence:

   1) The current outside air temperature must be above 38°F.
   2) The previous day's maximum outside air temperature had to exceed 78°F.
   3) The night flush schedule must be active (Initially set for 3am – 5:30am)
   4) The average space temperature must be above the Night Flush Space Cooling Setpoint (initially set at 68°F).

D. If rooms with operable windows cool to their occupied heating set point, close their operable window.

E. If the average of spaces meets the occupied heating temperature, shut down the night flush.

F. All system heating modes shall be locked out during and 4 hours after the night flush routine has been implemented.

G. During natural economizer mode (at any heat pump) and during the night flush cycle, maintain the atrium differential pressure at a -0.01" wc.

   1. Open the inlet dampers on exhaust fans EF-S1, EF-S2 and EF-S3 in sequence as needed.
   2. When the building pressure is more positive than the set point and the smoke exhaust fan inlet motorized dampers are proven open, activate lead fan (EF-S1, EF-S2 or EF-S3 in lead lag manner). Operate fan at minimum VFD speed and slowly increase as needed to maintain atrium space pressure set point of -0.01" wc. As needed, cycle on remaining fans, and ramp together.

H. EF-S1, EF-S2 or EF-S3 in lead lag manner alternating lead fan weekly, based on operator input.

1.5 HEAT PUMP WATER LOOP

A. A water source heat pump loop serves multiple load side heat pumps throughout the building. The loop will fluctuate between the lower range of 40°F to the upper range of 90°F. A ground source geothermal closed loop shall be the primary source of heating and cooling. Supplemental heat is provided by the heating hot water system. When the heat pump loop is between the upper and lower limits, the system will be in dead band allowing the load side heat pumps to transfer energy with no external source of heating and cooling. The load side heat pumps utilize two way valves, so the heat pump loop is variable flow. Buffer tanks provide an element of thermal mass storage to optimize transitional loads and optimize storage of the geothermal source.

   1. A variable speed drive shall be provided on the geo-exchange loop pumps, and primary heat pump loop pumps.
B. Heat Pump Loop Cooling

1. Loop tuning and ramping adjustments shall be optimized to provide smooth transitions between stages and to optimize the geothermal loop.
2. Cooling shall be heat rejection into the geothermal loop.
3. The Geothermal Cooling Control Loop shall use the temperature sensor (HPLGT_LWT) located after the geothermal taps but prior to the heating hot water injection. The loop shall modulate to maintain the Loop Cooling Setpoint (initially set at 85°F).
   a. The geothermal pumps (P-GS1, P-GS2) shall cycle, in a lead/lag manner, based on the Heat Pump Cooling Control Loop. The lead pump shall be rotated weekly, as set by the building operator. If the lead pump fails to prove status the lag pump shall start. Transitions from lead to lag pump shall occur in a smooth ramp transition with both pump operating so the system flow is not interrupted.
   b. Upon further cooling demand the pump speed shall be modulated from minimum frequency (20 hz or as recommended by the pump manufacturer) to maximum frequency (60 hz or as set by the test and balance contractor).
   c. Each pump is sized for 100% capacity, so other than lead/lag transition, only one pump shall run at a time.
   d. Provide a 15 minute minimum runtime.

C. Heat Pump Loop Heating

1. Loop tuning, ramping adjustments shall be optimized to provide smooth transitions between stages and to optimize geothermal prior to introduction of heating hot water.
2. First stage of heating shall be heat injection from the geothermal loop. Second stage of heating shall be via the heating hot water injection.
3. The Geothermal Heating Control Loop shall use the temperature sensor (HPLGT_LWT) located after the geothermal taps but prior to the heating hot water injection. The loop shall modulate to maintain the Geo Loop Heating Setpoint (initially set at 40°F).
   a. The geothermal pumps (P-GS1, P-GS2) shall cycle in a lead/lag manner. The lead pump shall be rotated weekly, as set by the building operator. If the lead pump fails to prove status the lag pump shall start. Transitions from lead to lag pump shall occur in a smooth ramp transition with both pumps operating so the system flow is not interrupted.
   b. Upon further heating demand the pump speed shall be modulated from minimum frequency (20 hz or as recommended by the pump manufacturer) to maximum frequency (60 hz or as set by the test and balance contractor).
   c. Each pump is sized for 100% capacity, so other than lead/lag transition, only one pump shall run at a time.
   d. Provide a 15 minute minimum runtime.
4. The Hot Water Injection Control Loop shall use the temperature sensor (HPLS) located at the heat pump loop supply to the load heat pumps prior to the buffer tanks. The loop shall modulate to maintain the HPLS Loop Heating Setpoint (initially set at 37°F). This loop shall be disabled until the Geo heating loop is at 100% for more than 5 minutes. It shall be the primary control loop if the geothermal pumps are inactive for any reason. Provide anti-wind and/or transitional ramps upon invoke to prevent load surges to the hot water system.
   a. A two way modulating valve shall inject heating hot water in proportion to the Hot Water Injection Control Loop and transitional ramps.
   b. Verify heat is entering the loop via a BTU meter located on the line feeding from the hot water heating loop into the heat pump loop. Ramp heat loop pump P-HW motor speed as needed to provide heat if heat is not entering loop.
5. Geothermal saturation could occur during periods of extreme extended use. If the heating rejection BTU’s, with geothermal pump at 100%, are below the Geothermal Heating Saturation setpoint (Initially set for 800 btu/minute) for more than 30 minutes initiate a Geothermal Heating Saturation Mode. This shall remain latched until either reset by an operator or an automatic restart delay (initially set at 10 hours). During the Geothermal saturation mode, the geothermal pumps shall be disabled and the heating hot water shall revert as the primary Heating source.

D. Heat Pump Loop Pump Sequence (P-HP1, P-HP2):

1. Occupied Mode: The building heat pump loop shall run continuously in occupied periods.
2. Unoccupied Mode: The building heat pump loop shall cycle as needed upon call from any load side heat pump. Provide a 15 minute minimum run time.
3. Each pump is sized for 100% capacity. Configure the pumps in a lead/lag manner. Alternate Lead/Lag every week on Tuesdays at 10:00 AM.
   a. Heat Pump loop flow must be maintained during lead/lag transfer. When transferring pumps, start lag pump and prove flow before stopping the lead pump, constantly maintaining the system differential pressure at or above set-point

4. On a loss of flow by the lead pump, the lag pump shall automatically start with an alarm indication at the graphical interface that the lead pump has failed.
5. A variable speed drive shall be provided on the building circulation pumps.
   a. The VFD shall modulate to maintain the system differential pressure setpoint. The differential pressure transducer shall be installed at the furthest point in the piping system. The T.C. contractor shall work with the balance contractor to determine a set point.
   b. 33% (20 Hz) shall be the minimum pump speed (or as recommended by the Pump manufacturer).

E. Alarming

1. Provide alarm for all pump failures.
2. Alarm if HPLS temperature is at or above 95°F for more than 5 minutes.
3. Alarm if HPLS temperature is below 35°F for more than 5 minutes.
4. Alarm if Geothermal Cooling Saturation Mode is active
5. Alarm if Geothermal Heating Saturation Mode is active
6. Provide alarm for the system glycol feeder low level alarm
7. Monitor heat pump loop system pressure and provide alarm if system is outside of normal range. Provide status for glycol feeder pump, and log runtime and cycles. Alarm if continuous on time exceeds 10 minutes, or if pump cycles more than 2 times in a 24 hour period.
8. Reference Points List for additional alarm and monitoring points.

1.6 Heating Hot Water System:

1. Hot Water System Enable: The heating hot water system shall be enabled whenever either outdoor interlock is active or the heat pump loop is calling for supplemental heat.
2. To avoid system operation during transition spring/fall weather, the outdoor interlocks shall be broken into two distinct interlocks
   a. Outdoor Interlock1 shall become active whenever outside air temperature is below the OA Interlock1 Setpoint (Initially set at 62°F) for more than 12 hrs.
   b. Outdoor Interlock 2 shall become active whenever outside air temperature is below the OA Interlock2 Set point (Initially set at 38°F).
3. Primary Hot Water Pumps (HWP1, HWP2)
   a. The lead pump shall run continuously upon system enable.
   b. A variable speed drive shall be provided on the building circulation pumps. Each pump is sized for 100% capacity. Configure the pumps in a lead/lag manner. Alternate Lead/Lag every week, Tuesdays at 10:00 AM

1)  Heat loop flow through the HX must be maintained during lead/lag transfer. When transferring pumps, start lag pump and prove flow before stopping the lead pump.

c. Upon a loss of flow by the lead pump, the lag pump shall automatically start with an alarm indication at the graphical interface that the lead pump has failed.

d. The VFD shall modulate to maintain the system differential pressure set point. The differential pressure transducer shall be installed at the furthest point in the piping system. The T.C. contractor shall work with the balance contractor to determine a set point (Initially set at 15 PSID).

e. 33% (20 hz) shall be the minimum pump speed (or as recommended by the pump manufacturer).

f. System pumps shall run for 60 minutes after system enable to dissipate any residual heat in the heat exchangers.

4. Heating Hot Water Temperature
   a. The steam heat exchangers are 100% redundant. Operate in a lead lag manner. Close water side isolation valve after associate steam valve has been inactive for 60 minutes.
   b. The loop temperature set point shall be 130 Deg F in normal operating mode.
   c. The loop temperature set point shall be 190 Deg F in Emergency Power mode.
   d. Open the lead heat exchanger motorized 2-way valve.
   e. The 1/3 and 2/3 valves shall sequential modulate to provide seamless transition optimizing each or both valves. Modulate the 1/3 capacity steam valve open as needed to maintain the loop temperature set point. If the 1/3 capacity steam valve cannot maintain the loop temperature set point, transitional close the 1/3 valve while modulating the 2/3 capacity steam valve. Once the 2/3 valve is 100% open transition the 1/3 valve. Reverse signaling as demand decreases.

f. Steam valves shall fail closed.

g. Provide high water temperature limit control for each heat exchanger (initially set at 220°F). Interrupt power to steam control valves (close valves). Autoreset three times and then provide manual reset through DDC system.

5. Alarms
   a. Provide alarm for all pump failures.
   b. Provide alarm for the system glycol feeder low level alarm.
   c. Monitor heating loop pressure and alarm if outside normal range.
   d. High Water Temperature
   e. Low water temperature (20°F below setpoint for >30 minutes) when system is enabled.
   f. Reference Points List for additional monitoring and alarm points

1.7  WATER TO AIR HEAT PUMP SEQUENCE

A. The heat pump manufacturer shall provide a DDC controller with a BACNet interface for each heat pump. Interface to the heat pump controller terminals to enable heating, cooling, fan enable, fan speed, and DAT reset signal, per sequence. Provide all additional necessary sensors and valves not provided by the manufacturer of the heat pump to meet the control sequence specified below.
B. Unit Variances between heat pump sizes dictate signal interfacing and sequences.

1. Vertical Heat Pumps 3 tons or larger shall have modulating compressors and therefore will accept a discharge air reset signal (0-10VDC).
2. Horizontal heat pumps 5 tons or larger shall have two stage compressor and will not require the discharge reset sequence. Compressor staging shall be split proportionally with space heating/cooling demand with the fan speed modulation occurring on the last 2/3rds of the demand range.
3. Horizontal Heat pumps under 4 tons shall be single compressor. Compressor staging shall be the 1st half of demand and fan speed shall be the last half demand.

C. Provide all heat pumps with room sensors with an AAON logo. Room sensors accessible in public areas (bathrooms, corridors, entryways, etc.) shall be vandal proof, have a locking cover, or have adjustment disabled via software. Provide a room sensor schedule with submittal package. Design team and/or owner shall have final say as to sensor style at the time of submittal review. Sensors in non-public areas shall have set point adjustment and on/off buttons. Room sensors shall display current room temperature and setpoint at a minimum.

D. Occupancy Modes

1. All single room zones shall be connected to relay on dual technology occupancy sensors.
2. Software schedules shall be associated with heat pumps based on usage type (admin areas, classroom areas, etc.). Schedules shall incorporate holiday exceptions. Common area heat pump zones shall follow any active schedule.
3. When occupancy is sensed, the heat pump shall operate in the occupied mode, regardless of schedule. Occupant shall be able to override occupancy sensor and place the unit into the standby mode by pressing the off button at the room sensor. Manual mode sets shall revert to automatic at the next scheduled occupancy.
4. When occupants are not present for 15 minutes or more, and the associated occupancy schedule is active, set the unit to "standby mode" This will maintain the occupied set point less standby offset (initially 2°), cycle the fan.
5. When occupants are not present for 15 minutes or more, and the associated occupancy schedule is Inactive, set the unit to "unoccupied mode" This will maintain the unoccupied set points, and cycle the fan, and provide no ventilation.
6. Each zone shall incorporate an optimal start algorithm to optimize prestart of the unit to bring zone up to the occupied heating setpoint by the scheduled occupancy time. Initial early start of up to 3 hrs prior to occupancy.
7. Initial unoccupied set points shall be 60°F heating, 80°F cooling. Automatically reset heating setpoint up to 65°F during extreme cold weather.

E. SB UNITS: SINGLE ZONE VAV SEQUENCE:

1. Supply Fan:
   a. The supply fan shall be started according to the room occupancy mode. After the supply fan has started, the control sequence shall be enabled.
   b. The DDC system shall provide the unit with a fan speed signal. The intent would be to utilize the lowest fan speed possible under low loads. The fan speed can modulate from minimum to maximum based off the last stage of space heating/cooling demand, low discharge air limit, high discharge air limit, or speed shall proportionally track the primary ventilation air volume.
   c. Minimum fan speed shall be set to 50% of scheduled airflow and maximum shall be set to 100% of scheduled airflow. Provide independent min/max set points at the graphical level for adjustment by the TAB contractor.
d. Fan speed shall modulate as the final stage of zone heating/cooling (Exception: Units with Hot Water coil).
e. Fan speed shall increase based on a DAT low limit control loop. The DAT low limit control loop shall have an initial setpoint of 45°F.
f. Fan speed shall increase based on a DAT high limit control loop. The DAT high limit control loop shall have an initial setpoint of 110°F.
g. Fan speed shall proportionally track ventilation air volume minimum/maximum. When air volume is at its minimum volume, the fan shall be allowed to go to minimum speed, or as needed to satisfy the above stated conditions. As ventilation air volume increase, the fan speed must increase to lead ventilation air volume.
h. Note the shop spaces have some requirements for fan volume monitoring and control. See "SHOP EXHAUST AND SUPPLY AIR VOLUME CONTROL:" for more details on required interfaces.

2. Zone Control:

a. Each SB heat pump will be run as a single zone VAV system.
b. Each zone shall have a setpoint with deadband (initially set at 3°F). From the setpoint, an effective space heating and space cooling setpoint shall be derived. Space heating and space cooling demand shall be derived from independent control loops. Transitions to/from heating/deadband/cooling shall have delay capabilities with smooth transitions between modes.
c. The DDC system shall index the units reversing valves to provide heating or cooling per the zone demand.
d. DAT reset shall be maximized before increasing fan speed when applicable.
e. On specified units (as noted on the heat pump schedule) ventilation air shall be allowed as the first stage of cooling.
f. When applicable, the DDC system will provide a discharge air set point to the unit controller. The unit controller will modulate/cycle the heating/cooling system in sequence per the below diagrams of discharge/fan control. Max air temperature shall be set to 90 deg F and min air temperature shall be set to 50 deg F.

Heat Pump Hot Water Coil, Auxiliary Heat control: Where the heat pump is outfitted with a hot water coil, use the hot water as a second stage of heat. Modulate the two way valve as needed to maintain the space temperature.
3. Water Control Valve: When the compressor is commanded to activate, the heat pump shall open the control valve on the heat pump loop water. The heat pump will prove flow prior to activating compressor.

4. Ventilation

   a. Ventilation shall be measured and control via a cross flow sensor located in the fresh air duct.

   b. Each zone shall have a CO2 sensor in the space. During occupied mode, the IAQ control loop (initial setpoint 1000ppm) shall generate a demand signal. The demand signal shall modulate ventilation air from its min air volume setpoint to its maximum air volume setpoint. Fan speed shall track proportionally.

   c. No ventilation air shall be provided during unoccupied or standby modes. Ventilation damper shall drive to 0%.

   d. Some heat pumps (as noted on heat pump schedule) shall allow ventilation air to increase from min to max as a form of economizer cooling. This will be allowed only if the primary AHU is not supplementing the discharge air with heat or mechanical cooling.

   e. Some heat pumps (as noted on heat pump schedule) shall allow ventilation air via GC provided motorized window actuators.

      1) See the Mechanical Plans for motorized window locations.
      2) Window ventilation shall be the first stage of cooling provided the outside air temperature is lower than the space temperature. Primary ventilation air shall be driven closed.
      3) Where a dedicated exhaust VAV is provided for a space: When windows are open, close fresh air VAV while leaving exhaust VAV open.
      4) When mechanical cooling is enabled, close windows.
      5) Smoke control shall supersede all other sequencing of windows

   f. Ventilation damper shall drive to 0% on loss of fan status to prevent reverse rotation of fan when it is off.

   

   ![Horizontal Unit VAV Control Diagram]

F. Safety Interlocks
1. A local Duct Smoke Detector shall shut off fan on heat pumps 2000 CFM or larger. Addressable Duct Smoke detectors and contacts are furnished by fire alarm system. Assist fire alarm contractor with point of connection to factory control wiring.

2. Fire alarm system shall shut down all heat pumps over 2000 cfm and any heat pumps that serve the atrium upon activation of Atrium smoke control sequence. Other units shall be shut down via DDC interlock.

3. Provide remote reset of factory fault lockout for all heat pumps.

4. Globally deactivate all compressor demand signals upon loss of flow, high temperature alarm, or low temperature alarm of the primary heat pump loop.

G. HORIZONTAL UNITS: SINGLE VARIABLE SPEED FAN SEQUENCE:

1. Supply Fan Start/Stop: The supply fan will be started according to the schedule. After the supply fan has started, the control sequence will be enabled.
   a. Note the shop spaces have some requirements for fan volume monitoring and control. See "SHOP EXHAUST AND SUPPLY AIR VOLUME CONTROL:" for more details on required interfaces.

2. Zone Control:
   a. Each heat pump will be run as a constant volume system during compressor operation. During compressor off or "satisfied" periods, reduce airflow to 75% (300 cfm/ton) of scheduled airflow.

3. Heat Pump Discharge Temperature Control: The DDC system will provide the unit controller a call for heating or cooling. The unit controller shall operate the unit to provide cooling or heating as the demand requires.

4. Fan Speed Control: The DDC system shall provide the unit a fan speed signal. The fan speed shall be constant speed, 100% of schedule airflow, during compressor operation. During compressor off or "satisfied" periods, reduce airflow to 60% of scheduled airflow. Override as ventilation needs dictate.

5. The reversing valves will be indexed to provide heating or cooling per the zone demand.

6. Water Control Valve: When the compressor is commanded to activate, open the control valve on the heat pump loop water. The heat pump will prove flow prior to activating.

H. Night Setback/Night Setup: When in "unoccupied" mode, the unit will cycle as necessary to maintain the night setback zone temperature at set point. A differential prevents the unit from cycling excessively.

I. Shut Down: When the unit is shut down by either a stop command or system safety, the unit will be set as follows:
   1. Supply fan will be off
   2. Compressors will be off

J. Each heat pump sensor will provide a space set point control with readout and space temperature readout.

1.8 SPACE PRESSURIZATION CONTROL

A. Poll and monitor the total CFM of all the fresh air VAV boxes.
B. Poll and monitor the total CFM of all the exhaust air VAV boxes.

C. Maintain the building in a positive pressure mode. Maintain a supply minus exhaust differential of 1000 cfm minimum for the building. If the exhaust requirement begins to climb above the differential, increase fresh air supply proportionally to all fresh air VAV boxes (proportioned to their fresh air minimum CFM) until the differential is met.

1.9 REST ROOM AND JANITOR EXHAUST AIR VOLUME CONTROL:
A. Maintain all rest rooms and janitor closets exhaust volume as follows:
   1. Maintain janitor closets and rest rooms at 50% of scheduled CFM unless occupancy sensor is activated, then maintain 100% of occupied CFM during any occupancy and for 10 minutes after any occupancy. Provide dual technology occupancy sensors as needed. Piggy back on sensors provided by EC where provided.

1.10 SHOP/LAB EXHAUST AND SUPPLY AIR VOLUME CONTROL:
A. Objective: Minimize exhaust to allow lower fresh air quantities into the building (reduce energy consumption)
B. Shop /Lab exhaust control:
   1. Shops and Labs where VOC's may be present:
      a. Under any occupied condition, it is the intent that the shop/labs remain negative to the adjacent areas.
      b. Modulate exhaust volume from its minimum to maximum air volume on VOC demand from space.
      c. Zone ventilation supply air shall track the exhaust air less the offset (Initially set at -10%).
      d. When supply air volume demand is increasing by other means (economizer cooling, manual override, etc.), modulate exhaust to track the supply volume plus offset (initially 10%).
      e. Utilize an Airquity brand system (or equal) to monitor the air quality and modulate the exhaust airflow requirement in the space.
   2. Shops and labs where VOC's are not anticipated: Shop supply volume control:
      a. The exhaust VAV shall match the heat pump supply air volume + 10%. Note that the heat pumps are single zone/variable air volume units.
   3. Provide necessary airflow sensors, etc. as needed in the case that the Aaon heat pump controller cannot provide necessary outputs.

1.11 DOMESTIC WATER HEATER OPERATION/INTERFACE (DWH-1)
A. The domestic water system will consist of a water to water heat pump, circulation pump and storage tank with a heat exchanger. See the plans for piping schematics.
B. Connect the DDC system to the heat pump BacNet interface for control and monitoring.
C. Provide a temperature sensor in the tank at manufacturer’s recommended location.

D. Monitor the tank temperature. If the tank temperature drops below the set point:
   1. Activate the circulation pump when the tank temperature drops 5°F below set point (130°F).
   2. Activate heat pump to operate off of its packaged controls and provide hot water to the tank HX.
   3. Deactivate domestic water heater when the tank temperature is at set point. Pump stays operating for 5 minutes after the heat pump deactivates (or as required by the heat pump manuf).

E. Provide the following alarms/connections:
   1. High and low temperature alarm for tank.
   2. Provide a DDC connection to the heat pump controls for a trouble alarm.
   3. Pump status alarm upon pump failure.
   4. Reference Points List for additional monitoring and alarm points.

F. Provide a DDC btu meter on this system. Track energy use via the BTU meter. Trend on the control system. Utilize a magnetic flow meter and DDC temperature sensors appropriate for this application.

1.12 WATER COOLED AIR COMPRESSOR AC-1

A. The air compressor for the building is water cooled. Provide a 3-way mixing valve to ensure the water entering the compressor cooler is above 40 deg F (confirm manufacturer minimum temperature recommendation).

1.13 DEDICATED OUTDOOR AIR SYSTEM SEQUENCE (DOAS-1) and ECON-1

A. General Overview: A dedicated outdoor air system (DOAS) providing variable volume tempered outdoor air serving the VAV terminals. It also incorporates a variable volume exhaust system serving the exhaust VAV terminals. A heat wheel is incorporated to allow heat extraction from the exhaust air to preheat the tempered supply air. The total VAV supply demand can exceed the capacity of the DOAS unit, so a supplemental Economizer air system (ECON-1) shall supplement the supply air volume with 100% un-tempered air. A solar wall shall allow pre-warming of the outside air when required. A bypass damper allows an alternate air path when no preheat is required (economizer cooling, warm/hot outside air conditions).

B. An air to water heat pump component shall allow modulating cooling/heating functionality as the primary source. A hot water preheat coil shall act as a frost prevention for the heat wheel. A final hot water heating shall provide any additional heat requirements.

C. The DOAS system is served from emergency power, so it will be utilized as the primary building heat source during loss of commercial power.

D. The temperature control contractor shall provide and install actuators for the motorized dampers in the intake and outlet of DOAS-1. Provide status for each and alarm up on failure.

E. The Building Automation System shall provide the following hardwired interfaces with the DOAS-1 standalone DDC controller:
   1. Unit start command
   2. Supply and exhaust fan speed control signal, and discharge set-point (0-10VDC or 4-20mA) to the unit controller or VFD’s. Coordinate with DOAS-1 supplier.
F. Modulate supply and exhaust fan VFD speeds based on duct static pressure.

G. Provide and install all field mounted temperature sensors for DOAS-1.

H. Sequence of operation

1. BMS INTERFACE –Temperature Control Contractor to Confirm with ERU supplier.
   a. BACnet over IP / BACnet Ethernet compatible (see attached variable table)
   b. BACnet MSTP compatible (see attached variable table).

2. Fan Operation
   a. DOAS supply fan/dampers shall be enabled whenever any the total VAV Ventilation Demand is greater than the supply fan start threshold (Initially set at 500 CFM). A minimum on/off time shall be 15 minutes
   b. DOAS exhaust fan/dampers shall be enabled whenever the total Exhaust Demand is greater than the exhaust fan start threshold (Initially set at 500 cfm). A minimum on/off time shall be 15 minutes
   c. ECON-1 fan/dampers shall be enabled whenever the DOAS supply fan speed is greater than 99% and the duct static is 5% lower than its setpoint for 5 minutes. ECON-1 shall become disabled if its DOAS speed is less than 80% for more than 5 minutes. A minimum on/off time shall be 15 minutes. Corresponding actuators shall open and damper status proven prior to starting the respective fan. Dampers should delay closing until fan status has been off for 30 seconds.

3. Fan Speed Control
   a. Modulate the supply fan speed to maintain the supply duct static pressure (initially set at 1"wc). Locate duct static sensor 2/3rds down the supply duct. Note location on the graphical floor plans to aid future service.
   b. The first half the supply duct static control loop shall be scaled to the DOAS supply fan speed. The second half of the supply duct static control loop shall be scaled to the ECON-1 fan speed.
   c. Modulate the exhaust fan speed to maintain the exhaust duct static pressure (initially set at 1"wc). Locate ducts static sensor 2/3rds down the exhaust duct. Note location on the graphical floor plans to aid future service.
   d. ECON-1 fan speed shall be automatically limited if discharge air temperature falls below the low discharge air limit (initially set at 50°F).

4. Temperature Control:
   a. The discharge air temperature (DAT), located in the common supply duct from DOAS serving the VAV’s, shall be maintained at the discharge air heating and cooling set points. The discharge air heating set point shall be reset based on the minimum zone heating demand in accordance with the following reset schedule:

<table>
<thead>
<tr>
<th>Minimum Zone Htg Demand</th>
<th>DAT Heating Set point</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 %</td>
<td>50°F</td>
</tr>
<tr>
<td>100%</td>
<td>70°F</td>
</tr>
</tbody>
</table>
The discharge air cooling setpoint shall be reset based on the maximum economizer cooling demand from any heat pump in accordance with the following reset schedule:

<table>
<thead>
<tr>
<th>Maximum Econ Clg Demand</th>
<th>Discharge Heating Air Set point</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 %</td>
<td>70°F</td>
</tr>
<tr>
<td>100%</td>
<td>55°F</td>
</tr>
</tbody>
</table>

There is potential for the DOAS supply leaving air temperature (DOAS-LAT) to be lower or higher than the DAT depending on the ECON-1 contribution. Therefore, a limiting function shall not allow the DOAS-LAT to fall below at low limit setpoint (Initially set at 50°). A high limit function shall prevent the leaving air temperature from exceeding its high limit setpoint (Initially set at 70°F).

b. The solar wall is a passive means of preheating the outdoor air prior to the DOAS. It shall be used as the first stage of preheat. A mixing damper prior to the DOAS shall be modulated to trim the heating capacity of the solar wall.

1) During generator operation, close the west solar wall intake.

c. Heat Wheel shall be utilized to its optimal performance prior to other mechanical means

1) Whenever outside air temperature is below the discharge air setpoint, and the exhaust air temperature is greater than the outside air temperature plus 5°F; the heat wheel shall be enabled to preheat. The heat wheel shall be scaled as first stage of preheat if solar wall is not in play. Heat wheel will be scaled with solar wall as first stage when solar wall is in play.

2) Whenever the outside air is above the discharge air setpoint, and the exhaust air is below the outside air temperature minus 5°F; the heat wheel shall be enabled to precool. The heat wheel speed shall be scaled as the first stage of discharge cooling demand.

3) It is anticipated that the heat wheel will be de-active during periods when the outside air temperature is between 55-75°F.

4) The heat wheel has the potential to frost the exhaust air surface during extreme cold weather. The preheat coil prior to the heat wheel shall prevent this. Modulated the preheat to maintain the leaving air temperature (heat wheel supply entering air temperature) setpoint (initially set at 5°F). Modulate the preheat to maintain the heat wheel exhaust leaving air temperature setpoint (Initially set at 20°F). The maximum demand from either loop shall drive the preheat valve. Whenever the supply fan is inactive, set preheat setpoint to 50° to keep unit from getting too cold during inactive periods.

d. Heat Pump Operation shall be the primary mechanical cooling method, and be optimized to its fullest prior supplemental heating with the hot water coil.

1) Heat pump shall accept a cool enable signal whenever the DAT is greater than the discharge air cooling setpoint + 3°F for a time period, indicating that economizer cooling is no longer able to meet the demand. Once enabled the discharge air reset signal to the heat pump shall correspond to the effective DAT cooling setpoint.

2) Heat pump shall accept a heat enable signal whenever the DAT is less than the discharge air heating setpoint for a time period. Once enabled the discharge air reset signal to the heat pump shall correspond to the effective DAT heating setpoint. Lock out the heat pump when the entering air temperature is below the manufacturer's recommendations.

3) Deadbands, minimum mode transition timers, and inter-stage delays shall be incorporated as needed to prevent undesirable mode transfers. The goal being to
maintain a steady state mode (heating or cooling) to allow factory packaged discharge air to find a steady state of discharge air control.

5. The Final Hot Water Coil shall be implemented after heat pump capacity no longer meets demand, or the heat pump is locked out due to low entering air temperature. Scale the final heating coil control valve off the discharge heating control loop as needed to maintain the discharge air heating setpoint. Emergency Heat Mode: In the event of a power outage and the outside air temperature is below 55 deg F, enable DOAS-1 Emergency heat mode.

   a. Monitor space temperatures. If the average of the space temperatures is 55 deg F or lower, or any space is 40 deg F or lower, start heating the space.
   b. Activate the pre-heat and final heating coils and adjust the discharge air temperature to maintain the average space at 55 deg F, or until the coldest space achieves 45 deg F. Limit the discharge air temperature to 120 deg F.
   c. When in emergency mode, run the heating coil at maximum to provide heat to the building, based upon an average of the building thermostats.

6. Pricing Alternate (provide separate line item price for this item labeled Alternate TC1): Monitoring for MSU: Provide a BTU meter for the heat pump serving the DOAS unit for MSU research purposes.

I. Pricing Alternate (provide separate line item price for this item labeled Alternate TC2): Monitoring for Research Purposes:

1. Provide a thermal sensor array to monitor the West Solar Wall for research purposes. The sensor array shall be 4 sensors wide by 4 sensors (10K thermistor) tall per the following figure.
2. Provide duct temperature sensor for main duct from solar wall.
3. Provide duct velometer in four duct connections from west solar wall.
Install temperature sensors in the air cavity at the locations noted by red dots. These can be typical HVAC (water resistant) thermistors used in ductwork. CFM measurements (or velocities) will also be required for each inlet locations (4 total). Install these flow measurement devices in the straight sections to get more accurate measurements. These locations are noted on MTH-32. A weatherstation with solar irradiance measurement will be required to be located on the building as well. Preferably in close proximity to the solar wall.

Figure 1 - WEST SOLAR WALL TEMPERATURE MONITORING PER KEVIN AMENDE
1.14 AHU-1 HEAT PUMP HEATING AND COOLING/ECONOMIZER/HEAT WHEEL, CO2 CONTROL ON FRESH AIR

A. Provide AHU with independent occupied/unoccupied schedules.

B. SUPPLY FAN

1. START/STOP: The supply fan will be started based on occupancy schedule. When the supply fan status indicates the fan started, the control sequence will be enabled. Upon a loss of airflow, the system will attempt to automatically restart until positive status is received.

C. RETURN FAN:

1. When the supply fan is started a command to the return fan shall be sent. If the return fan status does not match the commanded value, an alarm shall be generated.

D. SPEED CONTROL/DISCHARGE AIR CONTROL/CARBON DIOXIDE CONTROL:

1. CO2 sensor below alarm point:

   a. When the zone temperature is between the occupied heating and cooling set points (inside of the bias), the unit shall run at minimum CFM (See AHU Schedule for this value) and compressor shall be off.

   b. When the zone temperature rises above the zone temperature set point:

      1) Activate the economizer, if available. Modulate the mixing dampers to maintain a discharge air temperature of 55 deg F.

      2) If economizer is not available, the reversing valves will be indexed to provide cooling when the compressor is running. Modulate the compressor to maintain a discharge air temperature of 55 deg F.

      3) Increase (modulate) the CFM to maximum as needed to meet the space set point.
c. When the zone temperature falls below the zone temperature set point, the reversing valves will be indexed to provide heating when the compressor is running. The system operates as follows to maintain the zone temperature set point:

1) From 0-50% loop signal: The increase the discharge air temperature and control the unit fan speed to provide the scheduled minimum CFM. Set the maximum discharge air temperature at 90°F.

2) From 50% to 100% loop signal, maintain the 90 deg F discharge air temperature and modulate the unit supply airflow from minimum to the maximum airflow set point as needed to meet the space temperature set point. Once the set point is met, modulate the unit fan speed the damper back to minimum set point as needed to maintain the heating set point.

2. CO2 Control
   a. Increase first outside air and then fan speed from minimum at 700PPM to Maximum at 1200PPM.
   b. If the CO2 sensors reading exceeds the alarm set point of 1200 PPM for more than 1 hour, alarm the DDC system with a trouble alarm.
   c. Once the CO2 set point is met, modulate the fresh air damper to minimum position, then modulate the fan speed to maintain the space set point.

E. RETURN FAN TRACKING:

1. The return fan shall modulate in sequence with the supply fan. The return fan’s maximum and minimum system operating speeds will be determined and established during the Test and Balance phase in conjunction with the space’s supply and exhaust systems in their balanced operating state. The TC contractor shall record these speeds and lock-in the set-points on the VFD.

F. HEAT WHEEL OPERATION:

1. Heating Mode: When the unit is in heating mode, operate the heat wheel when the outdoor air temperature is below 70 deg F.
2. Cooling Mode: When the unit is in cooling mode, operate the heat wheel when the mixed air temperature is below 55 deg F or the outdoor air temperature is above 75 deg F.
3. Modulate the heat wheel speed to achieve the supply air temperature downstream of the heat wheel.

G. INTEGRATED DRY BULB ECONOMIZER SWITCHOVER: When the shared outside air temperature is below the switchover set point, the economizer shall be enabled. When the shared outside air temperature rises above the switchover set point plus a differential, the economizer shall be disabled. The switchover set point shall be the return air temperature.

H. FRESH AIR CONTROLS: The outdoor air setting (when not in economizer mode) shall modulate to maintain the scheduled minimum fresh air (see AHU schedule). Provide an airflow monitoring station on the fresh air intake and modulate the fresh air damper to maintain the fresh air set point when not in economizer mode, unless CO2 levels increase. On fan shut down the outdoor air damper shall close. The outdoor air damper shall fail in a closed position. The outdoor air damper shall remain closed in an unoccupied mode and during warm up. Alarm the DDC system if the fresh air drops below or exceeds the set point by more than 10% For a period of 30 minutes.

I. Keep the outdoor air damper closed in unoccupied times, in warm up periods and cool down periods, unless outdoor air is required per the cooling sequence of operations to cool down or maintain the setback temperature.
J. AHU SMOKE MODE

1. On an indication of a smoke detector or a fire alarm in the space served by this unit or by the unit smoke detector, the supply fan shall stop and the outdoor air damper shall close. Fire alarm relays furnished and wired by Electrical Contractor. The unit smoke detector shall be provided and installed by the Electric Contractor.

2. Wire as necessary to fire alarm control panel for signals required for smoke sensing.

K. FILTER STATUS

1. An Analog Differential Pressure Sensor across the filter bank and shall alarm the DDC system when filters are dirty.

L. SAFETIES:

1. All of the safety devices are manual reset; the device that has tripped must be manually reset before restarting the air handling unit.

2. If a temperature low limit sensor (located downstream of the heating coil) senses a temperature below set point the supplyfan and return fan shall be shutdown. The low limit set point shall be 35°F (adjustable).

3. A low static pressure switch located prior to the return fan senses a suction pressure that is greater than set point the supply fan and return fan shall be shut down. The low limit set point shall be -1” w.c. (adjustable).

4. If a high static pressure switch located after the supply fan senses a discharge pressure that is greater than set point, the supply fan and return fan shall be shutdown. The high limit set point shall be 2”w.c. (adjustable).

M. SHUTDOWN:

1. When the unit is shutdown by either a stop command or system safety the unit shall be set as follows:
   a. Supply fan shall be off
   b. Supply fan VFD shall be commanded to 0%
   c. Outside air damper shall close
   d. Return air damper shall open
   e. Exhaust air damper shall close
   f. Preheat valve shall remain in control

N. Unoccupied Mode:

1. If the spaces fed by the unit are above their Unoccupied cooling set point, enable economizer if available, or utilize mechanical cooling until economizer becomes available. If the spaces fed by the unit are below their Unoccupied heating set point, enable the AHU fan and heating coil to operate until the set point is met and then cycle the unit off. Provide a minimum 5 minute run time in both heating and cooling modes.

O. Building Warm-up Mode

1. Provide a building warm-up mode whenever the outdoor air temperature is below 45°F and coming out of unoccupied mode. Begin the warm up period based on the ASHRAE 90.1 optimum start algorithm (optimum start controls: controls that are designed to automatically adjust the start time of an HVAC system each day with the intention of bringing the space to desired
occupied temperature levels immediately before scheduled occupancy). Operate the system as indicated in the “occupied mode” portion of the sequence, but with the outdoor air damper closed.

1.15 FIN TUBE CONTROLS
A. FIN TUBE: When the Heating Hot Water System is enabled, the fin tube heaters shall be allowed. The fin tube hot water valve shall cycle as the first stage based off the space heating demand.

1.16 CABINET UNIT HEATER CONTROLS
A. CUH: When the space temperature is below the set point, open the hot water valve and activate the fan, if present. Do not activate the fan if hot water heating system is not enabled.
B. Vandal proof sensor shall be used in the vestibules and stair towers.

1.17 ELEVATOR SHAFT - GRAVITY VENTILATORS
A. Provide 24V operation of motorized dampers (spring return fail open) at the gravity ventilators located at the top of the elevator shafts (typ of 2). Dampers to be opened during any fire alarm event. The fire alarm contractor will provide a dry contact for interlocking. TC to provide actuator, power, etc. and monitor on DDC system.

1.18 CORRIDOR LINK FROM NAH TO PARKING GARAGE - VENTILATION
A. Provide controls to activate two exhaust fans (EF-5, 6) and one motorized louver (located in space) when the temperature in this space exceeds 78 deg F.
B. When the temperature reaches 70 deg F, turn fans off and close louver.

1.19 WEATHER STATION
A. Provide a weather station for this building as needed for monitoring of solar irradiance, precipitation, humidity, CO2 level, wind speed and direction and temperatures.

1.20 ELEVATOR SUMP PIT - TYP OF 2:
A. Provide water sensor in each elevator pit. Provide water alarm on DDC system as well as local alarm at elevator equipment room. Provide local alarm with silence switch.

1.21 FOUNDATION DRAIN SYSTEM SUMP PUMPS:
A. TC to wire pump system packaged controls.
B. Provide DDC alarm for high water and lead pump failure. Connect to packaged controls as needed. Provide relays, wiring, etc. as needed to accomplish this.
1.22 BASEMENT SEWAGE SUMP PUMPS:

A. TC to wire pump system packaged controls.

B. Provide DDC alarm for high water and lead pump failure. Connect to packaged controls as needed. Provide relays, wiring, etc. as needed to accomplish this.

1.23 SUMMER AND SCHOOL YEAR SCHEDULING

1. Maximum scheduling flexibility will be required for heat pumps and energy recovery units to allow for summer time scheduling. Each heat pump and energy recovery unit shall be provided with the capability for independent scheduling by the user.

2. Provide a “summer schedule” that includes operation of user specified heat pumps during user specified hours.

3. Provide a school year schedule for fully system operation during user specified hours.

1.24 STAGGERED STARTUP UPON POWER FAILURE

A. Stagger the start up of the mechanical equipment including (in this order) the pumps, Air Handlers, heat pumps (start at 1st floor and work up, start basement units last), DOAS-1 after the power failure. Provide this function to prevent all of the equipment from starting at once. Provide a 30 second delay between each component minimum. Purpose: to prevent power overload.

END OF SECTION 23 09 93.11
SECTION 23 21 13 - HYDRONIC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes pipe and fitting materials and joining methods for the following:

1. Hot-water heating piping.
3. Heat Pump Loop-water piping.
4. Makeup-water piping.
5. Condensate-drain piping.
7. Air-vent piping.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of the following:

1. Plastic pipe and fittings with solvent cement.
2. RTRP and RTRF with adhesive.
3. Pressure-seal fittings.

B. LEED Submittals:

1. Product Data for Credit IEQ 4.1: For solvent cements and adhesive primers, documentation including printed statement of VOC content.

C. Delegated-Design Submittal:

1. Design calculations and detailed fabrication and assembly of pipe anchors and alignment guides, hangers and supports for multiple pipes, expansion joints and loops, and attachments of the same to the building structure.
2. Locations of pipe anchors and alignment guides and expansion joints and loops.
3. Locations of and details for penetrations, including sleeves and sleeve seals for exterior walls, floors, basement, and foundation walls.
4. Locations of and details for penetration and firestopping for fire- and smoke-rated wall and floor and ceiling assemblies.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.
1.4 QUALITY ASSURANCE


PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature unless otherwise indicated:

1. Hot-Water Heating Piping: 100 psig at 200 deg F.
2. Condenser-Water Piping: 100 psig at 150 deg F.
3. Makeup-Water Piping: 80 psig at 150 deg F.
4. Condensate-Drain Piping: 150 deg F.
5. Blowdown-Drain Piping: 200 deg F.
6. Air-Vent Piping: 200 deg F.
7. Safety-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

2.2 COPPER TUBE AND FITTINGS

A. Drawn-Temper Copper Tubing: ASTM B 88, Type L.
B. Annealed-Temper Copper Tubing: ASTM B 88, Type K.
C. DWV Copper Tubing: ASTM B 306, Type DWV.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Anvil International.
   b. Star Pipe Products.
   c. Victaulic Company.

2. Grooved-End Copper Fittings: ASTM B 75, copper tube or ASTM B 584, bronze casting.
3. Grooved-End-Tube Couplings: Rigid pattern unless otherwise indicated; gasketed fitting. Ductile-iron housing with keys matching pipe and fitting grooves, prelubricated EPDM gasket rated for minimum 230 deg F for use with housing, and steel bolts and nuts.

E. Wrought-Copper Unions: ASME B16.22.

2.3 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; welded and seamless, Grade B, and wall thickness as indicated in "Piping Applications" Article.
B. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125 and 250 as indicated in "Piping Applications" Article.


D. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in "Piping Applications" Article.

E. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 25, 125, and 250; raised ground face, and bolt holes spot faced as indicated in "Piping Applications" Article.

F. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
   2. End Connections: Butt welding.
   3. Facings: Raised face.

G. Grooved Mechanical-Joint Fittings and Couplings:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Anvil International.
      b. Central Sprinkler Company.
      c. Grinnell Mechanical Products.
      d. National Fittings, Inc.
      e. Nexus Valve, Inc.
      f. S.P. Fittings.
      g. Smith-Cooper International
      h. Star Pipe Products.
      i. Victaulic Company.
   2. Joint Fittings: ASTM A 536, Grade 65-45-12 ductile iron; ASTM A 47/A 47M, Grade 32510 malleable iron; ASTM A 53/A 53M, Type F, E, or S, Grade B fabricated steel; or ASTM A 106/A 106M, Grade B steel fittings with grooves or shoulders constructed to accept grooved-end couplings; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.
   3. Couplings: Ductile- or malleable-iron housing and EPDM gasket of central cavity pressure-responsive design; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.
   4. Owner requests

2.4 PLASTIC PIPE AND FITTINGS

A. CPVC Plastic Pipe: ASTM F 441/F 441M, with wall thickness as indicated in "Piping Applications" Article.

B. PVC Plastic Pipe: ASTM D 1785, with wall thickness as indicated in "Piping Applications" Article.

2.5 JOINING MATERIALS

A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
   a. Owner requests "Garlock" Graphonic Gaskets for all flanged systems. Submit prior approval for equals.

B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

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

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

E. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BAg-1, silver alloy for joining copper with bronze or steel.

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

G. Solvent Cements for Joining Plastic Piping:
   1. CPVC Piping: ASTM F 493.
      a. CPVC solvent cement shall have a VOC content of 490 g/L or less.
      b. Adhesive primer shall have a VOC content of 550 g/L or less.
      c. Solvent cement and adhesive primer shall comply with the testing and product requirements of the California Department of Public Health's (formerly, the California Health Services') "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

   2. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.
      a. PVC solvent cement shall have a VOC content of 510 g/L or less.
      b. Adhesive primer shall have a VOC content of 550 g/L or less.
      c. Solvent cement and adhesive primer shall comply with the testing and product requirements of the California Department of Public Health's (formerly, the California Health Services') "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

H. Gasket Material: Thickness, material, and type suitable for fluid to be handled and working temperatures and pressures.

2.6 TRANSITION FITTINGS

A. Plastic-to-Metal Transition Fittings:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
2. One-piece fitting with one threaded brass or copper insert and one solvent-cement-joint end of material and wall thickness to match plastic pipe material.

B. Plastic-to-Metal Transition Unions:

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

   b. IPEX USA LLC.
   c. KBI (King Bros. Industries).
   d. Viega LLC.

2. Brass or copper end, solvent-cement-joint end of material and wall thickness to match plastic pipe material, rubber gasket, and threaded union.

2.7 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.

B. Dielectric Unions:

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

   a. A.Y. McDonald Manufacturing Company.
   b. Capitol Manufacturing Company.
   c. Central Plastics Company.
   d. HART Industrial Unions, LLC.
   e. Jomar Valve.
   f. Matco-Norca.
   g. Watts.
   h. Wilkins.

2. Zum Industries, LLC

   Description:

   b. Pressure Rating: 125 psig minimum at 180 deg F.
   c. End Connections: Solder-joint copper alloy and threaded ferrous.

2.8 BYPASS CHEMICAL FEEDER

A. Description: Welded steel construction; 125-psig working pressure; 5-gal. capacity; with fill funnel and inlet, outlet, and drain valves.
1. Chemicals: Specially formulated, based on analysis of makeup water, to prevent accumulation of scale and corrosion in piping and connected equipment.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. Hot-water heating piping, aboveground, NPS 2 and smaller, shall be any of the following:
   1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered or brazed or pressure-seal joints.
   2. Schedule 40, Grade B, Type 96 steel pipe; Class 125, cast-iron fittings; cast-iron flanges and flange fittings; and threaded joints.

B. Hot-water heating piping, aboveground, NPS 2-1/2 and larger, shall be any of the following:
   1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered or brazed joints.
   2. Schedule 40, Grade B, Type 96 steel pipe; Class 125, cast-iron fittings; cast-iron flanges and flange fittings; and welded joints.

C. Hot-Water Heating Piping Installed Belowground and within Slabs: Type K, annealed-temper copper tubing, wrought-copper fittings, and brazed joints. Use the fewest possible joints.

D. Heat Pump-water piping, aboveground, NPS 2 and smaller, shall be any of the following:
   1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered or brazed or pressure-seal joints.
   2. Schedule 40 steel pipe; Class 125, cast-iron fittings; cast-iron flanges and flange fittings; and threaded joints.

E. Heat Pump-water piping, aboveground, NPS 2-1/2 and larger, shall be any of the following:
   1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered or brazed joints.
   2. Schedule 40 steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.

F. Heat Pump-Water Piping Installed Belowground and within Slabs: Type K, annealed-temper copper tubing, wrought-copper fittings, and brazed joints. Use the fewest possible joints.

G. Makeup-water piping installed aboveground shall be the following:
   1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.

H. Makeup-Water Piping Installed Belowground and within Slabs: Type K, annealed-temper copper tubing, wrought-copper fittings, and soldered joints. Use the fewest possible joints.

I. Condensate-Drain Piping: Type M, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.

J. Blowdown-Drain Piping: Same materials and joining methods as for piping specified for the service in which blowdown drain is installed.
K. Air-Vent Piping:
   1. Inlet: Same as service where installed with metal-to-plastic transition fittings for plastic piping systems according to piping manufacturer's written instructions.
   2. Outlet: Type K, annealed-tempered copper tubing with soldered or flared joints.

L. Safety-Valve-Inlet and -Outlet Piping for Hot-Water Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed with metal-to-plastic transition fittings for plastic piping systems according to piping manufacturer's written instructions.

3.2 PIPING INSTALLATIONS

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

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

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

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

E. Install piping to permit valve servicing.

F. Install piping at indicated slopes.

G. Install piping free of sags and bends.

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

I. Install piping to allow application of insulation.

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

K. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

L. Install drains, consisting of a tee fitting, NPS 3/4 ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

M. Install piping at a uniform grade of 0.2 percent upward in direction of flow.

N. Reduce pipe sizes using eccentric reducer fitting installed with level side up.

O. Install branch connections to mains using tee fittings in main pipe, with the branch connected to the bottom of the main pipe. For up-feed risers, connect the branch to the top of the main pipe.

P. Install valves according to Section 23 05 23.11 "Globe Valves for HVAC Piping," Section 23 05 23.12 "Ball Valves for HVAC Piping," Section 23 05 23.14 "Check Valves for HVAC Piping," and Section 23 05 23.15 "Gate Valves for HVAC Piping."
Q. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

R. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.

S. Install shutoff valve immediately upstream of each dielectric fitting.

T. Comply with requirements in Section 23 05 16 "Expansion Fittings and Loops for HVAC Piping" for installation of expansion loops, expansion joints, anchors, and pipe alignment guides.

U. Comply with requirements in Section 23 05 53 "Identification for HVAC Piping and Equipment" for identifying piping.

V. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 23 05 17 "Sleeves and Sleeve Seals for HVAC Piping."

W. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 23 05 17 "Sleeves and Sleeve Seals for HVAC Piping."

X. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 23 05 18 "Escutcheons for HVAC Piping."

3.3 DIELECTRIC FITTING INSTALLATION

A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.

B. Dielectric Fittings for NPS 2 and Smaller: Use dielectric unions.

C. Dielectric Fittings for NPS 2-1/2 to NPS 4: Use dielectric flange kits.

D. Dielectric Fittings for NPS 5 and Larger: Use dielectric flange kits.

3.4 HANGERS AND SUPPORTS

A. Comply with requirements in Section 23 05 29 "Hangers and Supports for HVAC Piping and Equipment" for hanger, support, and anchor devices. Comply with the following requirements for maximum spacing of supports.

B. Comply with requirements in Section 23 05 48 "Vibration and Seismic Controls for HVAC" for seismic restraints.

C. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet long.
2. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.
5. Provide copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.
6. On plastic pipe, install pads or cushions on bearing surfaces to prevent hanger from scratching pipe.

D. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:
   1. NPS 3/4: Maximum span, 7 feet.
   2. NPS 1: Maximum span, 7 feet.
   3. NPS 1-1/2: Maximum span, 9 feet.
   4. NPS 2: Maximum span, 10 feet.
   5. NPS 2-1/2: Maximum span, 11 feet.
   6. NPS 3 and Larger: Maximum span, 12 feet.

E. 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 1-1/4: Maximum span, 7 feet; minimum rod size, 3/8 inch.
   4. NPS 1-1/2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
   5. NPS 2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
   6. NPS 2-1/2: Maximum span, 9 feet; minimum rod size, 3/8 inch.
   7. NPS 3 and Larger: Maximum span, 10 feet; minimum rod size, 3/8 inch.

F. 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.

G. Support vertical runs at roof, at each floor, and at 10-foot intervals between floors.

3.5 PIPE JOINT CONSTRUCTION

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

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

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

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

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

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

A. Sizes for supply and return piping connections shall be the same as or larger than equipment connections.

B. Install control valves in accessible locations close to connected equipment.

C. Install bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.

D. Install ports for pressure gages and thermometers at coil inlet and outlet connections. Comply with requirements in Section 23 05 19 "Meters and Gages for HVAC Piping."

3.7 CHEMICAL TREATMENT

A. Fill system with fresh water and add liquid alkaline compound with emulsifying agents and detergents to remove grease and petroleum products from piping. Circulate solution for a minimum of 24 hours, drain, clean strainer screens, and refill with fresh water.

B. Add initial chemical treatment and maintain water quality in ranges noted above for the first year of operation.

C. Fill systems that have antifreeze or glycol solutions with the following concentrations:


3.8 FIELD QUALITY CONTROL

A. Prepare hydronic piping according to ASME B31.9 and as follows:

1. Leave joints, including welds, uninsulated and exposed for examination during test.
2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
3. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.
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.

B. Perform the following tests on hydronic piping:

1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
3. Isolate expansion tanks and determine that hydronic system is full of water.
4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times the "SE" value in Appendix A in ASME B31.9, "Building Services Piping."
5. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
6. Prepare written report of testing.

C. Perform the following before operating the system:

1. Open manual valves fully.
2. Inspect pumps for proper rotation.
3. Set makeup pressure-reducing valves for required system pressure.
4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
5. Set temperature controls so all coils are calling for full flow.
6. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, cooling towers, to specified values.
7. Verify lubrication of motors and bearings.

END OF SECTION 23 21 13
SECTION 23 21 13.33 - VERTICAL GEOTHERMAL HEAT EXCHANGE SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Division 01 Procurement and Contracting and Division 01 General Requirements, apply to this Section.

1.2 SCOPE OF WORK

A. Reference 2.02A.

B. The extent of ground heat exchanger work is indicated on the drawings and schedules, and by requirements of this section. The closed-loop ground heat exchanger consists of heat fusion joined high density polyethylene piping, to couple to the extended range water-source heat pump units to provide an ISO/ARI/ASHRAE 13256-1 (water/air) and ISO/ARI/ASHRAE 13256-2 (water/water) ground source closed-loop heat pump system. Extended range for the ISO/ARI/ASHRAE 13256-1/2 is defined for testing purposes as 32°F EWT for heating and 77°F EWT for cooling. Any extended range heat pump considered for this application must have performance tables detailing total cooling and heating capacity, heat rejection (cooling), heat absorption (heating), kw consumed and EER/COP in 10°F EWT increments, from 20°F to 110/120°F source water temperature. For each 10°F EWT increment, performance values shall be provided at three supply water flow rates with corresponding pressure drop data through the coaxial heat exchanger of the heat pump.

C. Water source heat pumps intended for open loop and boiler/chiller systems, which are rated at narrower EWT ranges on the ISO/ARI 13256-1/2 specification, are unacceptable.

1.3 INTENT

A. These Specifications are intended to define the contractor's Scope of Work, establish the quality and safety requirements, and set general precautions to protect further construction of the project. Incidental items not specified therein or not shown on the drawings but which are required and necessary to complete the work shall be furnished by the contractor in the best available quality.

1.4 WORK COMPLETED BY OTHERS

A. Any and all work not directly relating to the installation of the Closed-Loop Ground Heat Exchanger, as described in these Specifications and Drawings, shall be provided.

B. The location of the Closed-Loop Ground Heat Exchanger connection to the building heat pump system and the Terminal Point of Piping is shown on the drawing, or as defined by Mechanical Engineer. Refer to drawings.

1.5 SPECIFIC ITEMS TO BE FURNISHED BY THE CONTRACTOR
A. The contractor shall furnish all labor, supervision, proper equipment in good working condition, supplies, tools, and materials required to complete the Work as specified and as defined in the contract documents provided by the Design/Builder.

B. The contractor shall, as a minimum, provide the all safety equipment to meet the requirements of all applicable State and Federal codes and standards. Contractor shall meet all requirements of the Occupational Safety and Health Act of 1970 (OSHA), including all amendments.

C. The contractor shall lock and secure their equipment and storage areas. The Owner shall not be held responsible for loss of damage of any contractor's equipment, tools, materials or personal effects.

D. If necessary, the contractor may provide their own lockable field office which may be located in the designated staging area.

E. The contractor shall develop and follow procedures for controlling any and all health risks associated with fugitive dust and Worker protection. The contractor's procedure shall address keeping Workers protected and fugitive dust minimized during the Work.

F. The contractor shall be responsible for performing all testing and monitoring as well as maintaining all necessary documentation, as specified in OSHA 29 CAR 1926.62 and 1926.103. A copy of the test results and any other documentation required by these codes shall be available for inspection by Architect/Engineer on Site.

G. Contractor shall provide all HDPE pipe, fittings and grout submittals for engineer's approval prior to start of ground loop installation.

1.6 DELIVERY, STORAGE AND HANDLING

A. Pipe, fittings and bentonite grouting material shall be stored on Site in Owner's designated area that will not interfere with the operations of the Owner or the operation of the other contractors at the Site.

B. All pipe and fittings are to be sealed, to the satisfaction of the Engineer, to prevent debris, rodents and other foreign material from entering the piping system.

C. All u-bend coils shall be delivered under pressure with test caps in place from manufacturer, and verified for positive pressure test (example, Centennial CenFuse pressurized coils) to validate integrity of pipe prior to installation.

D. Contractor shall individually test each circuit for pressure integrity prior to loading in boreholes.

E. Palletized bentonite grouting materials are to be protected from the weather with a protective covering, to the satisfaction of the Engineer.

1.7 MATERIALS AND WORKMANSHIP

A. The contractor shall maintain adequate quality control to assure compliance with all items detailed in this specification.

B. All materials shall be new and of the type and quality specified and free from all defects of materials or workmanship which would adversely affect performance or service life of the installed Work, or which would cause unsightly or unworkmanlike appearance.
C. The Engineer shall have the right to inspect material at any time after delivery to the Site. Any material, which is damaged, defective, or does not meet requirements of this Contract may be rejected, and shall be corrected or replaced at the contractor's expense.

1.8 QUALITY CONTROL

A. The Architect/Engineer may, at any time, suspend any portion of the Work when satisfactory results are not being met or when results are doubtful.

B. The Work shall not proceed after suspension until the contractor makes necessary corrections to bring Work into compliance. The contractor shall not be entitled to additional compensation or an extension of time for the performance of this Contract in the event Architect/Engineer suspends Work due to contractor noncompliance or inability to produce satisfactory results in accordance with the Scope of Work and Specifications.

1.9 SITE RESTORATION AND CLEANUP

A. The contractor shall keep the premises clean and orderly at all times during the Work. Upon completion of the Work, the contractor shall repair all damage caused by equipment, remove all of their equipment, tools, materials, containers and debris and leave the project and staging area free of rubbish, protective materials or excess materials of any kind.

B. All wastes generated by the contractor shall be properly contained and disposed of in accordance with local State and Federal regulations.

C. A vacuum truck for removing drill cuttings and fluid may or may not be required. The contractor should provide this option and cost should other containment and management efforts pertaining to drill cutting and mud not meet site housekeeping requirements.

1.10 OPERATING SCHEDULE

A. Work schedule pending coordination with General Contractor.

1.11 QUALITY ASSURANCE

A. The contractor shall submit the following documentation within 10 days after the bid

B. Contractor's Qualifications: Firms regularly engaged in installation of closed-loop ground heat exchanger, and/or projects of similar scope of the type, material and size required; whose installations have been in satisfactory use in similar service for not less than five (5) years. The contractor shall supply, with the bid, information on past jobs of similar scope. The following information must be supplied:

1. Name of Project/ Customer
2. Location of Project
3. Customer Contact Name (Reference) with Phone Numbers
4. Project Designer/ Engineer
5. Date of Installation
6. Number of Boreholes
7. Depth of Boreholes
8. Subsurface Manifolding
C. Manufacturer's Qualifications: Firms regularly engaged in manufacture of closed-loop ground heat exchanger products and tools of the types, material and size required; whose products have been in satisfactory use in similar service for not less than three (3) years.

D. Installer's Qualifications – Vertical Loops:

1. The Drilling Contractor shall be licensed by the State or Province if applicable.
2. The Drilling Contractor shall have at least five (5) years of successful installation experience on projects with closed-loop ground heat exchanger Work and/or projects of similar scope to that required for this project. Drilling Contractor must have experience at mixing, pumping and injecting bentonite grouting materials from the bottom of the borehole to the top, including thermally enhanced versions. In addition, Design Team requires all key looping personnel to be International Ground Source Heat Pump Association (IGSHPA) Installer Accredited and/or successfully completed an IGSHPA Driller’s Accreditation Course.
3. All field personnel shall provide proof of current IGSHPA Installer Accreditation with associated fusion card or certificate from a major HDPE pipe vendor or distributor. Personnel without current IGSHPA Installer Accreditation are prohibited from working on this project.

E. Fabricator's Qualifications

1. Fabricators must have completed a certification training program offered by the International Ground Source Heat Pump Association (IGSHPA) or approved manufacturers’ certification program and shall have at least two (2) years of successful installation experience. The installation personnel must be able to prove CURRENT accreditation. The only acceptable method of joining buried plastic pipe systems is by heat fusion process. Each ground heat exchanger fabricator must have performed a fusion procedure under direct supervision of an IGSHPA Accredited Heat Fusion Technician, an IGSHPA approved manufacturer's certification program or a DOT certified heat fusion technician. Each certified technician must attend a retraining school annually. The contractor shall provide proof of current accreditations (IGSHPA) or certifications.

PART 2 - PRODUCTS

2.1 SCOPE

A. The Work covered under this section of the Specifications is intended to include the furnishing of all equipment, materials and labor reasonably incidental to the complete operating installation of the Closed-Loop Ground Heat Exchanger and pertaining equipment and all piping as indicated on the drawing.

2.2 DESCRIPTION OF WORK

A. The work included in this section of the Specifications consists generally of, but is not limited to the following major systems or categories of Work:

1. Ground heat exchanger including:
   a. Borehole system, including hole, u-bend assembly and grout.
   b. Header/manifold system, including trench, pipe and backfill.
   c. System start-up, including filling, flushing and purging the closed-loop ground heat exchanger. Coordinate with Mechanical Engineer.
2.3 MATERIALS AND PRODUCTS

A. Provide new piping materials and factory-fabricated piping products of size, types, pressure rating, temperature rating and capacities as indicated.

2.4 BASIC IDENTIFICATION

A. All boreholes and key header piping routes shall be noted with GPS coordinates on as-built documentation of the closed loop ground heat exchanger installation.

B. The contractor shall provide identification for the underground piping by using underground-type metallic tracer tape. Warning tape must be foil-backed, at least two inches wide with a continuous message printed every 36" or less reading "CAUTION GEOTHERMAL PIPELINE BURIED BELOW." The tape shall be highly resistant to alkalis, acids, and other destructive agents found in the ground.

C. The contractor shall provide identification for the underground piping in addition to the aforementioned metallic tracer tape using Electronic Marker System (EMS) ball markers over the first and last borehole of each header pair, and for any other key locations deemed sensitive in relationship to other infrastructure. EMS marker balls shall be of the type with discreet identification numbers for individual balls and coordinated with construction and as-built documents including GPS coordinates of boreholes and other key markers for future remote sensor identification using a compatible remote sensing locator device. Contractor shall submit specific EMS device and locator documentation for review and approval by Mechanical Engineer/Ground Loop Design team and Architect.

D. EMS balls shall be installed to manufacturer’s minimum recommended depth for remote sensing typically 5.0' or less below grade.

E. Pre-approved EMS balls and locator device:
   1. 3M EMS XR/iD ball markers
   2. 3M Dynatel Locator

F. Other remote EMS location devices may be considered pending submittal review.

2.5 CLOSED-LOOP GROUND HEAT EXCHANGER MATERIALS

A. The only acceptable pipe and fittings material for the underground portion of the ground heat exchanger is high-density polyethylene. Specifications for the polyethylene heat exchanger are as follows:

   1. General: All pipe and heat-fused material shall be manufactured from virgin polyethylene extrusion compound material in accordance with ASTM D-2513, Sections 4.1 and 4.2. Pipe shall be manufactured to outside diameters, wall thickness and respective tolerances as specified in ASTM D-3035-93 or D-2447. Pipe material shall be manufactured by Centennial Pipe or approved equal.

   2. Material: The material shall maintain a 160 psi Hydrostatic Design Basis at 73.4°F per ASTM D-2837 (DR11) and 110 psi Hydrostatic Design Basis at 73.4°F per ASTM D-2837 (DR15.5), and shall be listed in PPI TR4 as a PE3408 piping formulation. The material shall be a high-density extrusion compound having a minimum cell classification of PE345434C or higher as specified in ASTM D-3350 with the following exceptions: this material shall exhibit zero failure (F0) when tested for a minimum of 192 hours under ASTM D-1693, condition C, as required in ASTM D-3350.
3. Fittings shall meet the requirements of ASTM D-2683 (for socket fusion fittings) or ASTM D-3261 (for butt/saddle fusion fittings).

4. Dimensions

   a. Pipe with a diameter of less than 1-1/4" (nominal) shall only be manufactured in accordance with ASTM D-3035 with a dimension ratio (DR) of 11.
   b. Pipe with a diameter of 1-1/4" (nominal) through 2" (nominal) shall be manufactured in accordance with ASTM D-3035 with a minimum dimension ratio (DR) of 11.
   c. Pipe with a diameter or 3" (nominal) and larger shall be manufactured in accordance with ASTM D-3035 with a dimension ratio (DR) of 15.5.

5. Table of Water Pressure Rating at 73.4°F for DR, HDPE PE3408 Plastic Pipe:

   a. Dimension Ratio 11, Pressure Rating, psi 160 ASTM D-2837
   b. Dimension Ratio 15.5, Pressure Rating, psi 110 ASTM D-2837

6. Markings

   a. Sufficient information, including numerical markings every two (2) feet, shall be permanently marked on the length of the pipe. This information is defined by the appropriate ASTM pipe standard. All fittings shall also be similarly marked.
   b. Marked information shall include:

      1) Manufacturer's Name
      2) Nominal Size
      3) Pressure Rating
      4) Relevant ASTM Standards
      5) Cell Classification Number
      6) Date of Manufacture

7. All piping used for the u-bend heat exchanger (pipe located in the borehole) will have factory hot-stamped lengths impressed on the side of the piping indicating the length of the heat exchanger to that point. The length shall read "0" (zero) on one end and the actual heat exchanger total length on the other end.

8. Warranty: The pipe manufacturer shall provide a minimum warranty of fifty (50) years, non-prorate. The warranty shall be transferable.

9. Pre-approved HDPE pipe vendor:

   a. Centennial Plastics – CenFuse HDPE for headering and CenFuse pre-manufactured u-bend circuit coil assemblies

2.6 PIPE JOINING METHODS

A. The only acceptable method for joining the buried pipe system is by a heat fusion process.

B. Joining shall be the socket, butt, saddle fusion or electrofusion method in accordance with the pipe manufacturer's procedures. The fusion technician shall be properly trained and shall have executed quality fusion joints.

C. The u-bend assembly for the vertical bore hole shall be factory-manufactured or shop-fabricated in a controlled environment all circuits tested at 100 psi under quality control conditions and shall be constructed of the same material designation prior to delivery to the Site. The vertical heat exchanger
shall have a factory-fused u-bend with pipe lengths long enough to reach grade from the bottom of the bore so no field fusion welds are required below the header pit.

2.7 THERMALLY ENHANCED BENTONITE GROUT – VERTICAL LOOPS

A. Thermally enhanced grout is specified for this project. High-solids bentonite grout mixed at minimum 30% solids is required, unless state or local code requires a denser mix ratio, with a thermal enhancement minimum value of 0.90 btuh/ft/°F. Contractor to provide at least three (3) sample tests minimum, with results forwarded within 5 working days from date of sampling to engineer and loop design consultant:

1. At the start of loop installation (first borehole drilled)
2. At approximately 30% field completion
3. At discretion of Mechanical Engineer

B. First grout sample to be tested shall be harvested from first grout batch for first borehole and postmarked to testing firm the same day. No exceptions.

C. Additional tests may be required at the expense of the contractor should these tests fail to meet the minimum thermal conductivity value required.

D. Approved testing services for thermally enhanced grout:

3. Other, as approved by Mechanical Engineer or Loop Designer

E. Note: For projects requiring only a 0.40 or 0.45 btuh/ft/°F grout thermal conductivity, Engineer may waive grout thermal enhancement testing requirement.

F. Summary

1. Thermally-enhanced bentonite grout with a minimum rating of 0.90 btuh/ft/°F value shall be used to seal and backfill each vertical u-bend well bore of the closed-loop ground heat exchanger to insure proper thermal contact with the earth and to ensure the environmental integrity of each vertical bore column, with tremie line to be installed concurrent with u-bend installation. Grouting to be completed immediately upon reaching design total depth. Delay of grouting after the loop is installed is unacceptable. The grout shall be pressure-induced from the bottom of the borehole to the surface to eliminate the chance of voids or borehole bridging; grouting shall be accomplished with the tremie line to start grouting from the bottom of the borehole. Assumption of grouting by gravity drop is unacceptable. The grouting material shall remain in a plastic state (moldable) throughout the life of the system and shall not generate heat during the hydration process.

2. All boreholes shall be loaded with pipe to total depth (TD) with tremie line and grouted immediately upon drilling and reaching design TD. Delay of grouting after the loop is installed is unacceptable.

3. Normal settling after the bore is completed may require topping off of the hole prior to backfilling the manifold or header trench / pit. If the settling has not exceeded 10’ below grade, the specified grout must be used for backfilling of settled boreholes.

4. No other backfill material shall be accepted.

5. Submittals - Manufacturer's published data sheets including thermal conductivity, permeability, percent solids, grout weight, linear shrinkage potential, maximum particle size and unit yield along with verification of the required listing(s).

G. Quality Assurance
1. Grouting compound shall be certified and listed by NSF (National Sanitation Foundation International) to ANSI/NSF Standard 60, "Drinking Water Treatment Chemicals - Health Effects".

H. Product

1. Manufacturer/Product
   a. Grouting material shall be one of Black Hills Bentonite's Thermal Grout products as supplied by GeoPro, Inc. or pre-approved equivalent. The thermal enhancement compound (high-grade silica sand and/or graphite) shall also be specified and supplied by the developer and supplier of the bentonite base material. Approved suppliers are GeoPro, Inc. and Baroid Industrial Drilling Fluids.

2. Thermal Conductivity Determination, Grout
   a. The thermal conductivity of the grouting compound must be 0.90 btuh/ft/°F as determined when tested in accordance to ASTM D-5334, "Standard Test Method for Determination of Thermal Conductivity of Soils and Soft Rock by Thermal Needle Probe Procedure". The reported thermal conductivity value shall be verified by an independent company which has a minimum of 5 years’ experience in measuring thermal conductivity using this method. A copy of the verification report shall be supplied upon request from the Engineer. Substituted grouts that are unknown to the design team shall be tested by a testing service selected by the Mechanical Engineer at the expense of the contractor or vendor.

3. Permeability
   a. The grout mixture shall also have a maximum permeability rate of less than 6.9 x 10-8 cm/s as determined by using ASTM D-5084, "Measurement of Hydraulic Conductivity of Saturated Porous Materials using a Flexible Wall Permeameter, Method C - test with increasing tailwater level". The reported permeability shall be verified by an independent lab with a copy of the report being supplied upon request from the engineer.

4. Total Solids and Enhancement Compound Percentage
   a. The thermally enhanced bentonite grout used shall have a minimum manufacturer’s recommended mixture of 30.0% solids, or higher if required by local or state code. The thermal enhancement compound (high-grade silica compound) shall constitute a minimum of 50% by weight of the aqueous slurry, or as required by the manufacturer to achieve the minimum thermal conductivity value required.

5. Installed Material Set
   a. The installed grouting material shall be fully set into a putty consistency within a minimum of 4 hours after being pressure pumped in the vertical bore annulus.

6. Packaging
   a. Bentonite and thermal enhancement compound shall be pre-manufactured and pre-packaged prior to delivery to the job site.

2.8 HORIZONTAL BACKFILL MATERIAL – MANIFOLDS & HEADERS
A. Fill shall be extracted from excavation spoils. Bedding for HDPE headers and manifolds shall be fines sifted from spoils as suitable for bedding horizontal ground heat exchangers, to a minimum of 24" above header and manifold lines. Should the type of fill used be in question, a representative sample shall be examined by the Engineer or Engineer's loop design consultant for approval.

PART 3 - EXECUTION

3.1 GENERAL SCOPE OF FIELD INSTALLATION

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total boreholes</td>
<td>104</td>
</tr>
<tr>
<td>U-bend depth from bottom of headering trench</td>
<td>500'</td>
</tr>
<tr>
<td>Maximum bit diameter</td>
<td>6.00&quot;</td>
</tr>
<tr>
<td>Circuit size</td>
<td>1¼&quot; DR11 HDPE</td>
</tr>
<tr>
<td>Header pairs</td>
<td>8</td>
</tr>
<tr>
<td>Header pair size</td>
<td>4.00&quot; DR15.5</td>
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<tr>
<td>Subsurface manifold reducing manifold schedule</td>
<td>Refer to GHX detail sheet</td>
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<tr>
<td>Minimum subsurface headering depth</td>
<td>8.0'</td>
</tr>
<tr>
<td>Boreholes per header pair</td>
<td>13</td>
</tr>
<tr>
<td>Bore spacing on each header lineament</td>
<td>20'</td>
</tr>
<tr>
<td>Grout thermal enhancement value, minimum</td>
<td>0.90 btuh/ft/°F</td>
</tr>
</tbody>
</table>

3.2 GENERAL INSTALLATION REQUIREMENTS

A. Inspect work in conformance with applicable division 23 section.

3.3 COORDINATION

A. The contractor selected to install the closed-loop ground heat exchanger shall coordinate his Work activities with the Mechanical and General Contractor.

B. All testing procedures shall be coordinated with the General Contractor Construction Manager or its designated representative(s).

C. CONTRACTOR shall communicate and document loop installation progress using appropriate nomenclature of ground heat exchanger headering and borehole schedule. For example, the header pairs for this project are designated A through F; boreholes of each header pair are numbered A1, A2, etc. Refer to site plan with ground heat exchanger layout for full description.

3.4 INSPECTION

A. Examine areas and conditions under which ground heat exchanger systems are to be installed. Do not proceed with Work until unsatisfactory conditions have been corrected in a manner acceptable to manufacturer's recommendations.

B. Drilling progress, u-bend installation depth, individual circuit flow test, and pressure testing log shall be updated daily and forwarded electronically to design team every evening. Log form/spreadsheet shall be provided by Mechanical Engineer.
3.5 CLEANLINESS

A. During the installation, trash, soil and small animals shall be kept out of the pipe. This project is located in an urban environment and extra care shall be taken to avoid contamination of the loop by vandalism or other means of contamination. Ends of the pipe shall be sealed with fusion end-caps until the pipe is joined to the manifold circuit. Taped, clamped or other mechanical sealing methods of pipe ends are not acceptable.

3.6 INSTALLATION OF COMPONENTS

A. Boreholes

1. Drill bore hole in accordance with local, State or Federal requirements. Follow all requirements for borehole drilling as prescribed by the State of Province, and/or standard industry practice. If required by state law or code, the contractor will be responsible for receiving, permission in writing from the State of Province or appropriate agency prior to proceeding and shall be responsible for maintaining any drilling logs that may be required. Bore hole installation cannot proceed until the contractor has provided written proof of permission given by the proper regulating agency.

2. The borehole shall be completed barefoot (no casing) and of sufficient diameter to facilitate the installation of the u-bend assembly and a tremie pipe. Each u-bend assembly shall be factory or shop assembled using twice the required length of pipe and a fusion joined 180° u-bend attached in the mid-point of the pipe, so as to create a continuous flow path for the full length of the assembly. Grouting shall be immediate and concurrent with loop installation as per 2.07-B of this specification.

3. Contractor shall maintain drilling progress log provided by Engineer or Loop Designer to be completed daily unless otherwise agreed to in writing by Engineer or Loop Designer. This log shall describe hole depth reached, installed u-bend depth, circuit markings at bottom and end of circuits for each borehole, time to drill/grout/complete each hole, date drilled/completed, water flow test, pressure test – psi and duration, date of testing, and grout volume per borehole.

4. Each borehole shall be marked with a steel key post not less than three (3) foot above grade with bright yellow or red flagging.

5. Care shall be taken so that the sealed pipe ends do not “drop” into the open borehole below graded surface.

6. When bore holes are drilled with an air or mud-rotary drilling unit, the u-bend shall be staked and tied to prevent the assembly from “floating” out of the bore prior to the “setting” of the bentonite grout.

7. Bore hole locations shall be individually surveyed after drilling is complete but before horizontal trenching has started. The survey shall locate all bore holes accurately from one or more known local survey benchmarks. Final hole locations may be surveyed using a GPS unit.

B. Testing

1. It is the loop installer’s responsibility to verify the u-bend assembly for pressure integrity and that the pipe is free from kinks or other damage that could impair flow. If it is visible that an obstruction exists, the obstructed section of pipe shall be removed and replaced with an equal length section which is free of obstructions and re-attached by heat fusion.

2. Installation (U-Bend): Immediately after completion of the borehole, the pre-tested, water filled u-bend circuit assembly shall be inserted into the borehole, u-bend first. A stiffener which does not present potential damage to the assembly may be used to straighten the leading section of the assembly and to add counter weight for easier insertion.

3. Prior to sealing installed u-bend circuits until headering can be completed, each circuit shall be flow tested to a minimum of 9.1 gpm (1.25” DR11 pipe) to verify no obstructions are present in any circuit that could inhibit flow.

4. The assembly shall be filled with water and pressurized to achieve a minimum of 50 psi just prior to grouting. Pressure will increase as grouting proceeds. Assembly shall have no significant loss
vertically for a minimum of 60 minutes after completion of grouting. Allowances in pressure loss shall be made for expansion per pipe manufacturer's recommendations. At the conclusion of the test, the pipe ends shall be sealed with a fusion cap or fusion crimp.

5. Should any circuit testing as prescribed above result in an inconclusive integrity test, revert to 4 hour hydrostatic test (ASTM D 2837). If after testing to ASTM D 2837 standard and loop fails, replace loop.

6. Note: Antifreeze or inhibitors shall not be induced into borehole circuits at this time, which could inhibit final purging of air. If there is a concern that water filled loops may freeze near the surface, contractor shall blow sufficient water from circuit to a level of 5' below grade.

7. Care shall be taken so that the sealed pipe ends do not "drop" into the open borehole below graded surface resulting in lost access.

C. Completed header pairs, inclusive of ground loops

1. Once all borehole circuits are headered to manifolds, all header piping, manifolds and borehole circuits of closed-loop ground heat exchanger system shall be water filled and pressure tested to 100 psi for a minimum of one (1) hour prior to backfill of the trench (each header pair). Every weld shall be visually and physically examined. If any leaks are detected at a fusion joint, it shall be cut out and replace at which time that section shall be re-tested according to this section.

2. Pressure test caps with pressure gauge on one cap of each pair shall remain on completed header pairs and monitored daily to verify pressure integrity until mechanical tie-in is completed in mechanical room.

3. Should header pair testing prove inconclusive as described above (3.06.C.1), retest to ASTM D 2837 standard.

D. Earthwork

1. General:
   a. The horizontal ditches for the closed-loop ground heat exchanger header may be dug with a backhoe or other acceptable excavation device. Perform excavation of every description and of whatever substance encountered to the depths indicated on drawings. During excavation, deposit material suitable for backfill in an orderly manner, a sufficient distance from the excavation banks to avoid overloading and to prevent slides or cave-ins. Grade as necessary to prevent surface water from flowing into trenches or other excavations, and remove water accumulating therein by pumping or other acceptable method. Unless otherwise indicated, excavation shall be by open cut. Keep banks of trenches and excavation for structures as nearly vertical as practicable and where required, properly sheet and brace. Fill unauthorized excavation below levels indicated for pipe with sand.
   b. Compaction shall be completed to 95% of standard proctor density unless otherwise specified by A/E Team.
   c. Trench Excavation: Excavate true to line to a depth to provide at least five (5) feet above top of pipe and to provide clear space of not less than two (2) inches on either side of pipe. Grade bottom of trenches accurately to provide uniform bearing and support for each section of pipe on six (6) inches of utility grade bedding sand, or fine fill from excavation spoils, along its entire length.
   d. Shoring Requirements: Perform all shoring and sheeting that is required to protect the excavation and to safeguard employees in accordance with OSHA. Widen excavation to provide for space occupied by shoring and sheeting. Shoring shall meet the requirements of all applicable codes and regulations.
   e. De-Watering: Prevent surface water and subsurface or groundwater from flowing into excavations and from flooding project Site and surrounding area. Do not allow water to accumulate in excavations. Remove water to prevent softening of foundation bottoms, undercutting footings and soil changes detrimental to stability of sub-grades and foundations. Provide and maintain pumps, well points, sumps, suction and discharge lines and other de-
watering system components necessary to convey water away from excavations. Establish and maintain temporary drainage ditches and other diversions outside excavation limits to convey rain water and water removed from excavations to collecting or runoff areas. Do not use trench excavations as temporary ditches.

f. Driller to provide all means of providing fluid containment as necessary.
g. Asphalt paving over borefield raises susceptibility to settlement. Use grout to fill all settlement to bottom elevation of header trench.

E. Fusion Work

1. All fusion work shall be completed by personnel with a current fusion certification from a known HDPE pipe or fittings manufacturer, HDPE product distributor of known integrity, or equivalent independent training resource (i.e., IGHPA installer accreditation, etc.). Personnel must be prepared to show proof of training and current ability.

2. Equipment must be maintained in safe, reliable condition, and operator(s) shall maintain heater faces in clean condition.

3. Example fusion examples from scrap pieces may be asked for as required for destructive testing to examine cross-sections of fusion welds by engineer or engineer's representative.

4. Fusion equipment must be tested routinely during fusion work to demonstrate proper heater face temperature; fusion iron thermometers are not to be relied on for fusion die temperature readings. A digital pyrometer with proof of calibration is required for each fusion crew. Temperature stick crayons may be used for occasional testing but a digital pyrometer test is required for daily baseline testing.

| Socket fusion temperature range               | 500° to 525° F |
| Butt fusion temperature range                | 390° to 425° F |

F. Warranty

1. The Loop Installation Contractor shall provide a warranty for a period of five (5) years from the date of final acceptance for all goods, components, installations and implied performance for all systems that make up the closed loop Ground Heat Exchanger (GHX), inclusive of the vertical bore field.

2. If the GHX does not meet or exceed the above referenced warranty, Client may at its election either: (i) require the Loop Installation Contractor to promptly correct any defective or non-performing features at the Loop Installation Contractor's sole expense, or (ii) recover monetary damages from the Loop Installation Contractor for the price to accomplish the design services and physical construction remediation necessary to rectify the defect in the GHX.

3. The Loop Installation Contractor shall have access to test and verify any such claims of non-performing features.

4. Looping contractor warrants that the field is installed to the design engineer's specifications including bottom u-bend installation depth, grouting has been blended to the minimum thermal conductivity required, grout has been installed from u-bend depth to headering depth using recognized industry procedures and appropriate grouting apparatus, borehole spacing design requirements, the specified reducing manifold schedule and all HDPE pipe and fittings meet the design specifications. Looping contractor guarantees that the ground heat exchanger will be installed with no foreign solid contaminants in the circuits or header piping such as soil, sand, gravel or other materials.

5. Looping contractor shall provide a written warranty for workmanship as per these requirements.

3.7 FLUSHING AND PURGING

A. Before backfilling the trenches, all systems shall be flushed and purged of air and flow tested to ensure all portions of the closed-loop ground heat exchanger are properly flowing. A portable temporary purging pump and barrel or reservoir unit shall be utilized and shall consist of the following:
1. Purge Pump - High Volume and High Head to meet minimum air purge rate of 2'/second velocity  
2. Open Reservoir  
3. Filter Assembly with By-Pass  
4. Flow Meter on Return  
5. Pressure Gauge on Supply and Return  
6. Connecting Piping  
7. Connecting Hoses  

B. Using the purging unit described above, flush and purge each section free of air, dirt and debris. A minimum velocity of 2 feet/second in each piping section must be maintained for a minimum of fifteen (15) minutes to remove all air. A change of more than one (1) inch in the level of fluid in the purge pump tank during pressurization indicates air still trapped in the system. The flushing and purging operation shall be conducted with the supply and return lines to the building capped and sealed at the flange termination connection within the building. Supply and return lines to the building shall be filled as full as possible with water. Building MECHANICAL contractor will be responsible for flushing and purging the interior portion of the system and a final purging of the entire system, including the ground loop. The building MECHANICAL contractor shall be responsible for refilling 100% of the piping installed by the looping contractor with water or as otherwise specified in writing by the Engineer.

C. Utilizing the purging unit, conduct a pressure and flow test on the ground heat exchanger to ensure the system is free of blockage. If the flow test indicates blockage, locate blockage using manufacturer's recommendation, remove blockage, then re-purge and conduct the pressure and flow test again until all portions of the system are flowing properly. The flow test must be observed and approved by the General Contractor before the system is to be considered completed.

D. For this project, the calculated minimum purge pump performance for the longest header pair is based upon the current estimated maximum one-way line distance between the mechanical room and farthest header pair set, not including fittings, temporary piping, etc. Minimum purge rate per header pair currently is:

1. GHX minimum header pair purge performance anticipated, current calculation:
   - Minimum Flow Rate to achieve 2'/second: 118.3 gpm
   - Minimum Pressure Drop estimated for purge rate: 42 ft/hd or 18 psi

2. Note: Minimum purge pump requirement may be adjusted pending final header length(s) and/or other changes to final field configuration; current purge pump performance assumes a maximum length between the mechanical room purge ports and the start of the first borehole of the furthest header pair. In any case the flow rate is the minimum accepted flow rate for air removal; greater flow rate for air purging is desired.

E. Purge rate is for single header pair and circuit sub portion of each header set. Should the longest header line distance be greater the contractor must verify with the Mechanical Engineer the adjusted purging pressure drop. Contractor must provide proof of purge pump performance (manufacturer's pump curves or independent flow test provided by recognized pump vendor).

F. Purging shall be provided by looping contractor, coordinating with the mechanical contractor for the inside portion of the building.

G. Sequence of Purging:

1. All interior piping to the building circuits and heat pumps shall be isolated at the mechanical room manifold.
2. All header pairs shall be closed to the ground heat exchanger, except for the nearest pair to the purge ports.
3. Provide fine screen filtration sufficient to filter out fine dirt and pipe shavings during the purging process. Confirm purge pump, settling barrel and screening apparatus with Engineer prior to clean out effort.

4. The first header pair shall be completely charged with potable, clean water – no exceptions. The purge pump shall be activated to achieve the minimum of flow rate as calculated for the final longest header line distance. Circulation shall continue until all air bubbles and/or debris are no longer detected in the purge barrel; the process shall then be repeated in reverse flow until return flow is clean of air and debris.

5. The first header pair shall be isolated, and the second pair purged as per step 4. Repeat through all remaining header pairs.

6. Place all header pairs in common communication and purge remaining air from interior manifold; isolate.

7. Charge and purge all interior piping with heat pumps isolated to eliminate internal slag, pipe dope, etc., prior to cleaning out water/refrigerant coils of heat pumps. Use end jumper pipe at termination of parallel internal piping to clean interior loop; valve off when completed.

8. Commence charging and purging of air in internal piping through heat pumps, from farthest heat pump to nearest.

9. Isolate building circuit from loopfield.

H. Induce prescribed amount of antifreeze or inhibitor into ground heat exchanger while simultaneously rejecting clean water from return until all antifreeze is installed. Once antifreeze or other inhibitor solution is induced, close return water line back to system. Antifreeze or other constituent to be confirmed. Confirm final calculated volume and percent minimum with Engineer. Submit type and brand of antifreeze or inhibitor to Mechanical Engineer for approval before proceeding. No antifreeze required for this application.

I. Antifreeze will be 35% by volume, propylene glycol, and shall not exceed this volume percentage.

J. Circulate to mix for the purpose of eliminating viscosity slugs.

K. Open interior piping to communicate completely with ground heat exchanger, continue to circulate until well mixed prior to operation.

L. Lock return line down to purge barrel, pressurize to a minimum of 30 psi. Higher lock-down pressure is acceptable to maximum of 80 psi.

3.8 WARRANTY SUBMITTALS

A. The contractor shall supply, to the Architect, the following information prior to system acceptance and final payment:

1. IGSHPA and Fusion Certifications of key personnel
2. Licensing by presiding authority for closed loop installation
3. All warranties including material and labor
4. Manufacturer certifications
5. Supplier and manufacture warranties, guarantees, and certifications
6. One full set of complete, accurate, dimensioned, as-constructed installation drawings, hard copy and electronic (pdf)
7. Provide CAD drawing of as-built field drawings and any associated notes, or as acceptable to Engineer
SECTION 23 21 16 - HYDRONIC PIPING SPECIALTIES

PART 1 - GENERAL

1.1 SUMMARY
   A. Section includes special-duty valves and specialties for the following:
      1. Hot-water heating piping.
      3. Makeup-water piping.
      4. Condensate-drain piping.
      5. Blowdown-drain piping.
      6. Air-vent piping.
      7. Safety-valve-inlet and outlet piping.

1.2 ACTION SUBMITTALS
   A. Product Data: For each type of the following:
      1. Valves: Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.
      2. Air-control devices.
      3. Hydronic specialties.

1.3 CLOSEOUT SUBMITTALS
   A. Operation and maintenance data.

1.4 QUALITY ASSURANCE
   A. ASME Compliance: Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS
   A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature unless otherwise indicated:
      1. Hot-Water Heating Piping: 100 psig at 200 deg F.
      2. Heat Pump Loop-Water Piping: 100 psig at 150 deg F.
      3. Makeup-Water Piping: 80 psig at 150 deg F.
      4. Condensate-Drain Piping: 150 deg F.
5. Blowdown-Drain Piping: 200 deg F.
6. Air-Vent Piping: 200 deg F.
7. Safety-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

2.2 VALVES

A. Gate, Globe, Check, Ball, and Butterfly Valves: Comply with requirements specified in Section 23 05 23.11 "Globe Valves for HVAC Piping," Section 23 05 23.12 "Ball Valves for HVAC Piping," Section 23 05 23.14 "Check Valves for HVAC Piping," and Section 23 05 23.15 "Gate Valves for HVAC Piping."

B. Automatic Temperature-Control Valves, Actuators, and Sensors: Comply with requirements specified in Section 23 09 23.11 "Control Valves" Section 15901 "Control Valves."

C. Bronze, Calibrated-Orifice, Balancing Valves:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Armstrong Pumps, Inc
      b. Bell & Gossett
      c. Flow Design, Inc.
      d. Gerand Engineering Co
      e. Grinnell Mechanical Products
      f. Griswold Controls
      g. HCl
      h. Nexus Valve, Inc.
      i. NuTech Hydronic Specialty
      j. Oventrop Corp
      k. TACO
      l. Tour & Andersson
      m. Tunstall Corp
      n. Victaulic Co

   2. Body: Bronze, ball or plug type with calibrated orifice or venturi.
   3. Ball: Brass or stainless steel.
   4. Plug: Resin.
   5. Seat: PTFE.
   6. End Connections: Threaded or socket.
   8. Handle Style: Lever, with memory stop to retain set position.
   10. Maximum Operating Temperature: 250 deg F.

   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. AMTROL, Inc.
      b. Armstrong Pumps, Inc.
      c. Bell & Gossett
      d. Conbraco Industries, Inc.
e. Spence Engineering Co
f. Watts

2. Body: Bronze or brass.
3. Disc: Glass and carbon-filled PTFE.
5. Stem Seals: EPDM O-rings.
6. Diaphragm: EPT.
7. Low inlet-pressure check valve.
8. Inlet Strainer: Removable without system shutdown.
10. Valve Size, Capacity, and Operating Pressure: Selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.


1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. AMTROL, Inc.
   b. Armstrong Pumps, Inc.
   c. Bell & Gossett
   d. Conbraco Industries, Inc.
   e. Spence Engineering Co
   f. Watts

2. Body: Bronze or brass.
3. Disc: Glass and carbon-filled PTFE.
5. Stem Seals: EPDM O-rings.
6. Diaphragm: EPT.
8. Inlet Strainer: Removable without system shutdown.
10. Valve Size, Capacity, and Operating Pressure: Comply with ASME Boiler and Pressure Vessel Code: Section IV, and selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

F. Automatic Flow-Control Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   b. Flowcon Americas LLC
   c. Griswold Controls
   d. Hays Fluid Controls
   e. HCI
   f. Nexus Valve, Inc.
   g. NuTech Hydronic Specialty
   h. Tunstall Corp.

2. Body: Brass or ferrous metal.
3. Piston and Spring Assembly: Stainless steel, tamper proof, self-cleaning, and removable.
4. Combination Assemblies: Include bronze or brass-alloy ball valve.
5. Identification Tag: Marked with zone identification, valve number, and flow rate.
6. Size: Same as pipe in which installed.
7. Performance: Maintain constant flow, plus or minus 5 percent over system pressure fluctuations.
9. Maximum Operating Temperature: 250 deg F.

2.3 AIR-CONTROL DEVICES

A. Manual Air Vents:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. AMTROL, Inc.
   b. Armstrong Pumps, Inc.
   c. Bell & Gossett
   d. Nexus Valve, Inc.
   e. NuTech Hydronic Specialty
   f. TACO

2. Body: Bronze.
3. Internal Parts: Nonferrous.
4. Operator: Screwdriver or thumbscrew.
5. Inlet Connection: NPS 1/2.
7. CWP Rating: 150 psig.
8. Maximum Operating Temperature: 225 deg F.

B. Expansion Tanks:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. AMTROL, Inc.
   b. Armstrong Pumps, Inc.
   c. Bell & Gossett
   d. TACO

2. Tank: Welded steel, rated for 125-psig working pressure and 375 deg F maximum operating temperature, with taps in bottom of tank for tank fitting and taps in end of tank for gage glass. Tanks shall be factory tested after taps are fabricated and shall be labeled according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
3. Air-Control Tank Fitting: Cast-iron body, copper-plated tube, brass vent tube plug, and stainless-steel ball check, 100-gal. unit only; sized for compression-tank diameter. Provide tank fittings for 125-psig working pressure and 250 deg F maximum operating temperature.
4. Tank Drain Fitting: Brass body, nonferrous internal parts; 125-psig working pressure and 240 deg F maximum operating temperature; constructed to admit air to compression tank, drain water, and close off system.

C. In-Line Air Separators:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. AMTROL, Inc.
   b. Armstrong Pumps, Inc.
   c. Bell & Gossett
   d. TACO

2. Tank: One-piece cast iron with an integral weir constructed to decelerate system flow to maximize air separation.
4. Maximum Operating Temperature: Up to 300 deg F.

2.4 HYDRONIC PIPING SPECIALTIES

A. Y-Pattern Strainers:
   1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
   2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
   3. Strainer Screen: Stainless-steel, 60-mesh strainer, or perforated stainless-steel basket.

B. Stainless-Steel Bellow, Flexible Connectors:
   2. End Connections: Threaded or flanged to match equipment connected.
   4. CWP Rating: 150 psig.
   5. Maximum Operating Temperature: 250 deg F.

C. Expansion Fittings: Comply with requirements in Section 23 05 16 "Expansion Fittings and Loops for HVAC Piping."Section 15124 "Expansion Fittings and Loops for HVAC Piping."

PART 3 - EXECUTION

3.1 VALVE APPLICATIONS

A. Install shutoff-duty valves at each branch connection to supply mains and at supply connection to each piece of equipment.

B. Install calibrated-orifice, balancing valves at each branch connection to return main.

C. Install calibrated-orifice, balancing valves in the return pipe of each heating or cooling terminal.

D. Install check valves at each pump discharge and elsewhere as required to control flow direction.

E. Install safety valves at hot-water generators and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install drip-pan elbow on safety-valve outlet and pipe without valves to the outdoors; pipe drain to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, for installation requirements.
F. Install pressure-reducing valves at makeup-water connection to regulate system fill pressure.

3.2 HYDRONIC SPECIALTIES INSTALLATION

A. Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.

B. Install piping from boiler air outlet, air separator, or air purger to expansion tank with a 2 percent upward slope toward tank.

C. Install in-line air separators in pump suction. Install drain valve on air separators NPS 2 (DN 50) and larger.

D. Install expansion tanks above the air separator. Install tank fitting in tank bottom and charge tank. Use manual vent for initial fill to establish proper water level in tank.

   1. Install tank fittings that are shipped loose.
   2. Support tank from floor or structure above with sufficient strength to carry weight of tank, piping connections, fittings, plus tank full of water. Do not overload building components and structural members.

E. Install expansion tanks on the floor. Vent and purge air from hydronic system, and ensure that tank is properly charged with air to suit system Project requirements.

END OF SECTION 23 21 16
SECTION 23 21 23 - HYDRONIC PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   2. Close-coupled, end-suction centrifugal pumps.
   4. Separately coupled, vertically mounted, in-line centrifugal pumps.
   5. Separately coupled, base-mounted, end-suction centrifugal pumps.
   6. Automatic condensate pump units.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of pump.

B. Shop Drawings: For each pump.
   1. Show pump layout and connections.
   2. Include setting drawings with templates for installing foundation and anchor bolts and other anchorages.
   3. Include diagrams for power, signal, and control wiring.

1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 CLOSE-COUPLED, IN-LINE CENTRIFUGAL PUMPS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Armstrong Pumps, Inc.
   2. Grundfos Pumps Corporation
   3. ITT Corporation
   4. TACO, Inc.

B. Description: Factory-assembled and -tested, 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.

C. Pump Construction:
1. Casing: Radially split, cast iron, with threaded gage tappings at inlet and outlet, replaceable bronze wear rings, and threaded companion-flange connections.
2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. For constant-speed pumps, trim impeller to match specified performance.
4. Seal: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless-steel spring, and EPT bellows and gasket. Include water slinger on shaft between motor and seal.
5. Seal: Packing seal consisting of stuffing box with a minimum of four rings of graphite-impregnated braided yarn with bronze lantern ring between center two graphite rings, and bronze packing gland.

D. Motor: Single speed and rigidly mounted to pump casing.
   1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
   2. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 23 05 13 "Common Motor Requirements for HVAC Equipment."
      a. Enclosure: Open, dripproof.
      b. Enclosure Materials: Cast iron.
      c. Motor Bearings: Permanently lubricated ball bearings.
      d. Efficiency: Premium efficient.
      e. NEMA Design: A.
      f. Service Factor: 1.1.

E. Capacities and Characteristics:
   1. See Drawings.

2.2 CLOSE-COUPLED, END-SUCTION CENTRIFUGAL PUMPS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Armstrong Pumps, Inc.
   2. ITT Corporation
   3. TACO, Inc.

B. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, close-coupled, end-suction pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally.

C. Pump Construction:
   1. Casing: Radially split, cast iron, with replaceable bronze wear rings, drain plug at bottom and air vent at top of volute, threaded gage tappings at inlet and outlet, and flanged connections.
   2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. For constant-speed pumps, trim impeller to match specified performance.
4. Mechanical Seal: Carbon rotating ring against a ceramic seat held by a stainless-steel spring, and EPT bellows and gasket. Include water slinger on shaft between motor and seal.

5. Pump Bearings: Permanently lubricated ball bearings.

D. Motor: Single speed and rigidly mounted to pump casing with integral pump support.

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 23 05 13 “Common Motor Requirements for HVAC Equipment.”
   a. Enclosure: Open, dripproof.
   b. Enclosure Materials: Cast iron.
   c. Motor Bearings: Permanently lubricated ball bearings.
   d. Efficiency: Premium efficient.
   e. NEMA Design: A.
   f. Service Factor: 1.1.

E. Capacities and Characteristics:

1. See Drawings.

2.3 SEPARATELY COUPLED, BASE-MOUNTED, END-SUCTION CENTRIFUGAL PUMPS

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

1. Armstrong Pumps, Inc.
2. ITT Corporation
3. TACO, Inc.

B. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, separately coupled, end-suction pump as defined in HI 1.1-1.2 and HI 1.3; designed for base mounting, with pump and motor shafts horizontal.

C. Pump Construction:

1. Casing: Radially split, cast iron, with replaceable bronze wear rings, threaded gage tappings at inlet and outlet, drain plug at bottom and air vent at top of volute, and flanged connections. Provide integral mount on volute to support the casing, and provide attached piping to allow removal and replacement of impeller without disconnecting piping or requiring the realignment of pump and motor shaft.
2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. For pumps not frequency-drive controlled, trim impeller to match specified performance.
4. Seal: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless-steel spring, and EPT bellows and gasket.
5. Seal: Packing seal consisting of stuffing box with a minimum of four rings of graphite-impregnated braided yarn with bronze lantern ring between center two graphite rings, and bronze packing gland.
D. Shaft Coupling: Molded-rubber insert and interlocking spider capable of absorbing vibration. EPDM coupling sleeve for variable-speed applications.

E. Coupling Guard: Dual rated; ANSI B15.1, Section 8; OSHA 1910.219 approved; steel; removable; attached to mounting frame.

F. Mounting Frame: Welded-steel frame and cross members, factory fabricated from ASTM A 36/A 36M channels and angles. Fabricate to mount pump casing, coupling guard, and motor.

G. Motor: Single speed, secured to mounting frame, with adjustable alignment.
   1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
   2. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 23 05 13 "Common Motor Requirements for HVAC Equipment."
      a. Enclosure: Open, drip-proof.
      b. Enclosure Materials: Cast iron.
      c. Motor Bearings: Permanently lubricated ball bearings.
      d. Efficiency: Premium efficient.
      e. NEMA Design: A.
      f. Service Factor: 1.1.

H. Capacities and Characteristics:
   1. See drawings.

2.4 AUTOMATIC CONDENSATE PUMP UNITS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   2. Hartell Pumps
   3. Little Giant Pump Co
   4. Mepco, LLC

B. Description: Packaged units with corrosion-resistant pump, plastic tank with cover, and automatic controls. Include factory- or field-installed check valve and a 72-inch- minimum, electrical power cord with plug.

C. Capacities and Characteristics:
   1. See Drawings.

2.5 PUMP SPECIALTY FITTINGS

A. Suction Diffuser:
   1. Angle pattern.
   2. 175-psig pressure rating, cast-iron body and end cap, pump-inlet fitting.
   3. Bronze startup and bronze or stainless-steel permanent strainers.
   4. Bronze or stainless-steel straightening vanes.
5. Drain plug.
6. Factory-fabricated support.

B. Triple-Duty Valve:
   1. Angle or straight pattern.
   2. 175-psig pressure rating, cast-iron body, pump-discharge fitting.
   3. Drain plug and bronze-fitted shutoff, balancing, and check valve features.
   4. Brass gage ports with integral check valve and orifice for flow measurement.

PART 3 - EXECUTION

3.1 PUMP INSTALLATION

   A. Comply with HI 1.4.
   B. Install pumps to provide access for periodic maintenance including removing 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.
   D. Automatic Condensate Pump Units: Install units for collecting condensate and extend to open drain.
   E. Equipment Mounting:
      1. Install base-mounted pumps on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 03 30 53 "Miscellaneous Cast-in-Place Concrete."
      2. Comply with requirements for vibration isolation and seismic control devices specified in Section 23 05 48 "Vibration and Seismic Controls for HVAC."
      3. Comply with requirements for vibration isolation devices specified in Section 23 05 48.13 "Vibration Controls for HVAC."
   F. Equipment Mounting: Install in-line pumps with continuous-thread hanger rods and spring hangers with vertical-limit stop of size required to support weight of in-line pumps.
      1. Comply with requirements for seismic-restraint devices specified in Section 23 05 48 "Vibration and Seismic Controls for HVAC."
      2. Comply with requirements for hangers and supports specified in Section 23 05 29 "Hangers and Supports for HVAC Piping and Equipment."

3.2 ALIGNMENT

   A. Engage a factory-authorized service representative to perform alignment service.
   B. Comply with requirements in Hydronics Institute standards for alignment of pump and motor shaft. Add shims to the motor feet and bolt motor to base frame. Do not use grout between motor feet and base frame.
   C. Comply with pump and coupling manufacturers' written instructions.
D. 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.

3.3 CONNECTIONS

A. Comply with requirements for piping specified in Section 23 22 13 "Steam and Condensate Heating Piping" and Section 23 22 16 "Steam and Condensate Piping Specialties."

B. Drawings indicate general arrangement of piping, fittings, and specialties.

C. Where installing piping adjacent to pump, allow space for service and maintenance.

D. Connect piping to pumps. Install valves that are same size as piping connected to pumps.

E. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.

F. Install check valve and throttling valve with memory stop on discharge side of pumps.

G. Install Y-type strainer (for in-line pumps) and suction diffuser (for base mounted pumps) and shutoff valve on suction side of pumps.

H. Install flexible connectors on suction and discharge sides of base-mounted pumps between pump casing and valves.

I. Install pressure gages on pump suction and discharge or at integral pressure-gage tapping, or install single gage with multiple-input selector valve.

J. Install check valve and gate or ball valve on each condensate pump unit discharge.

K. Ground equipment according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."

L. Connect wiring according to Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

END OF SECTION 23 21 23
SECTION 23 22 13 - STEAM AND CONDENSATE HEATING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes pipe and fittings for LP and HP steam and condensate piping:

B. Related Requirements:

1. Section 23 22 16 "Steam and Condensate Piping Specialties" for strainers, flash tanks, special-duty valves, steam traps, thermostatic air vents and vacuum breakers, and steam and condensate meters.

1.3 ACTION SUBMITTALS

A. Product Data: For RTRP and RTRF and adhesive.

B. Delegated-Design Submittal:

1. Design calculations and detailed fabrication and assembly of pipe anchors and alignment guides, hangers and supports for multiple pipes, expansion joints and loops, and attachments of the same to the building structure.
2. Locations of pipe anchors and alignment guides and expansion joints and loops.
3. Locations of and details for penetrations, including sleeves and sleeve seals for exterior walls, floors, basement, and foundation walls.
4. Locations of and details for penetration and firestopping for fire- and smoke-rated wall and floor and ceiling assemblies.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Piping layout, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Suspended ceiling components.
2. Other building services.
3. Structural members.

B. Qualification Data: For Installer.

C. Welding certificates.

D. Field quality-control reports.
1.5 QUALITY ASSURANCE

A. Installer Qualifications:
   1. Fiberglass Pipe and Fitting Installers: Installers of RTRF and RTRP shall be certified by the manufacturer of pipes and fittings as having been trained and qualified to join fiberglass piping with manufacturer-recommended adhesive.

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

C. Pipe Welding: Qualify procedures and operators according to the following:
   2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working pressures and temperatures unless otherwise indicated:

   1. HP Steam Piping: 150 psig (45 psig system operating pressure).
   2. LP Steam Piping: 150 psig (10 psig operating pressure).
   3. Condensate Piping: at 250 deg F.
   4. Makeup-Water Piping: 30 psig at 150 deg F.
   5. Blowdown-Drain Piping: Equal to pressure of the piping system to which it is attached.
   6. Air-Vent and Vacuum-Breaker Piping: Equal to pressure of the piping system to which it is attached.
   7. Safety-Valve-Inlet and -Outlet Piping: Equal to pressure of the piping system to which it is attached.

2.2 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel, plain ends, welded and seamless, Grade B, and Schedule as indicated in piping applications articles.

B. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125, 150, and 300 as indicated in piping applications articles.

C. Malleable-Iron Threaded Fittings: ASME B16.3; Classes 150 and 300 as indicated in piping applications articles.

D. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in piping applications articles.

E. Cast-Iron Threaded Flanges and Flanged Fittings: ASME B16.1, Classes 125 and 250 as indicated in piping applications articles; raised ground face, and bolt holes spot faced.
F. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.

G. Wrought-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
   2. End Connections: Butt welding.
   3. Facings: Raised face.

H. Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M, black steel of same Type, Grade, and Schedule as pipe in which installed.

2.3 JOINING MATERIALS

A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
   1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch maximum thickness unless otherwise indicated.
      a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
      b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

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

D. Welding Materials: Comply with Section II, Part C, of ASME Boiler and Pressure Vessel Code for welding materials appropriate for wall thickness and for chemical analysis of pipe being welded.

PART 3 - EXECUTION

3.1 LP STEAM PIPING APPLICATIONS

A. LP Steam Piping, NPS 2 and Smaller: Schedule 40, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.

B. LP Steam Piping, NPS 2-1/2 through NPS 12: Schedule 40, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.

C. Condensate piping above grade, NPS 2 and smaller, shall be the following:
   1. Schedule 80, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.

D. Condensate piping above grade, NPS 2-1/2 and larger, shall be the following:
   1. Schedule 80, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.

E. Condensate piping below grade, NPS 2 and smaller, shall be the following:
3.2 HP STEAM PIPING APPLICATIONS

A. HP Steam Piping, NPS 2 and Smaller: Schedule 40, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.

B. HP Steam Piping, NPS 2-1/2 through NPS 12: Schedule 40, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.

C. Condensate piping above grade, NPS 2 and smaller, shall be the following:

1. Schedule 80, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.

D. Condensate piping above grade, NPS 2-1/2 and larger, shall be the following:

1. Schedule 80, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.

E. Condensate piping below grade, NPS 2 and smaller, shall be the following:

1. Schedule 80, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.

F. Condensate piping below grade, NPS 2-1/2 and larger, shall be the following:

1. Schedule 80, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.

3.3 ANCILLARY PIPING APPLICATIONS

A. Blowdown-Drain Piping: Same materials and joining methods as for piping specified for the service in which blowdown drain is installed.

B. Vacuum-Breaker Piping: Outlet, same as service where installed.

C. Safety-Valve-Inlet and -Outlet Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed.

3.4 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless otherwise indicated.

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

E. Install piping to permit valve servicing.

F. Install piping free of sags and bends.

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

H. Install piping to allow application of insulation.

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

J. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

K. Install drains, consisting of a tee fitting, NPS 3/4 full port-ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

L. Install steam supply piping at a minimum uniform grade of 0.2 percent downward in direction of steam flow.

M. Install condensate return piping at a minimum uniform grade of 0.4 percent downward in direction of condensate flow.

N. Reduce pipe sizes using eccentric reducer fitting installed with level side down.

O. Install branch connections to mains using tee fittings in main pipe, with the branch connected to top of main pipe.

P. Install valves according to Section 23 05 23.11 "Globe Valves for HVAC Piping," Section 23 05 23.12 "Ball Valves for HVAC Piping," Section 23 05 23.14 "Check Valves for HVAC Piping," and Section 23 05 23.15 "Gate Valves for HVAC Piping."

Q. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

R. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.

S. Install shutoff valve immediately upstream of each dielectric fitting.

T. Install strainers on supply side of control valves, pressure-reducing valves, traps, and elsewhere as indicated. Install NPS 3/4 nipple and full port ball valve in blowdown connection of strainers NPS 2 and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2.

U. Comply with requirements in Section 23 05 16 "Expansion Fittings and Loops for HVAC Piping" for installation of expansion loops, expansion joints, anchors, and pipe alignment guides.

V. Comply with requirements in Section 23 05 53 "Identification for HVAC Piping and Equipment" for identifying piping.
W. Install drip legs at low points and natural drainage points such as ends of mains, bottoms of risers, and ahead of pressure regulators, and control valves.

1. On straight runs with no natural drainage points, install drip legs at intervals not exceeding 100 feet.
2. Size drip legs same size as main. In steam mains NPS 6 and larger, drip leg size can be reduced, but to no less than NPS 4.

X. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 23 05 17 "Sleeves and Sleeve Seals for HVAC Piping."

Y. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 23 05 17 "Sleeves and Sleeve Seals for HVAC Piping."

Z. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 23 05 18 "Escutcheons for HVAC Piping."

3.5 STEAM AND CONDENSATE PIPING SPECIALTIES INSTALLATION

A. Comply with requirements in Section 23 22 16 "Steam and Condensate Piping Specialties" for installation requirements for strainers, flash tanks, special-duty valves, steam traps, thermostatic air vents and vacuum breakers, and steam and condensate meters.

3.6 HANGERS AND SUPPORTS

A. Comply with requirements in Section 23 05 29 "Hangers and Supports for HVAC Piping and Equipment" for installation of hangers and supports. Comply with requirements below for maximum spacing.

B. Comply with requirements in Section 23 05 48 "Vibration and Seismic Controls for HVAC" for seismic restraints.

C. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet long.
2. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.

D. Install hangers for steel steam supply piping with the following maximum spacing:

1. NPS 3/4: Maximum span, 9 feet.
2. NPS 1: Maximum span, 9 feet.
3. NPS 1-1/2: Maximum span, 12 feet.
4. NPS 2: Maximum span, 13 feet.
5. NPS 2-1/2: Maximum span, 14 feet.
6. NPS 3 and Larger: Maximum span, 15 feet.

E. Install hangers for steel steam condensate piping with the following maximum spacing:

1. NPS 3/4: Maximum span, 7 feet.
2. NPS 1: Maximum span, 7 feet.
3. NPS 1-1/2: Maximum span, 9 feet.
4. NPS 2: Maximum span, 10 feet.
5. NPS 2-1/2: Maximum span, 11 feet.
6. NPS 3 and Larger: Maximum span, 12 feet.

F. Support vertical runs at roof, at each floor, and at 10-foot intervals between floors.

G. Fiberglass 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.

3.7 PIPE JOINT CONSTRUCTION

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

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

C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
   1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
   2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

D. Welded Joints: Construct joints according to AWS D10.12M/D10.12, using qualified processes and welding operators according to "Quality Assurance" Article.

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

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

3.8 TERMINAL EQUIPMENT CONNECTIONS

A. Size for supply and return piping connections shall be the same as or larger than equipment connections.

B. Install traps and control valves in accessible locations close to connected equipment.

C. Install bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.

D. Install vacuum breakers downstream from control valve, close to coil inlet connection.

E. Install a drip leg at coil outlet.
3.9 FIELD QUALITY CONTROL

A. Prepare steam and condensate piping according to ASME B31.9, "Building Services Piping," and as follows:

1. Leave joints, including welds, uninsulated and exposed for examination during test.
2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
3. Flush system with clean water. Clean strainers.
4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Manufacturer’s Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

D. Perform the following tests and inspections:

1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
2. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength.
3. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.

E. Prepare test and inspection reports.

END OF SECTION 23 22 13
SECTION 23 22 16 - STEAM AND CONDENSATE PIPING SPECIALTIES

PART 1 - GENERAL

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

1.2 SUMMARY
   A. Section includes the following piping specialties for LP and HP steam and condensate piping:
      1. Strainers.
      2. Flash tanks.
      4. Pressure-reducing valves.
      5. Steam traps.
      6. Thermostatic air vents and vacuum breakers.
      7. Steam and condensate meters.

1.3 ACTION SUBMITTALS
   A. Product Data: For each type of the following:
      1. Pressure-reducing and safety valve.
      2. Steam trap.
      3. Air vent and vacuum breaker.
      4. Flash tank.
      5. Meter.

1.4 CLOSEOUT SUBMITTALS
   A. Operation and Maintenance Data: For valves, safety valves, pressure-reducing valves, steam traps, air vents, vacuum breakers, and meters to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE
   A. Pipe Welding: Qualify procedures and operators according to the following:
      1. ASME Compliance: Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp flash tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working pressures and temperatures unless otherwise indicated:

1. HP Steam Piping: 45 psig.
2. LP Steam Piping: 10 psig.
3. Condensate Piping: at 250 deg F.
4. Makeup-Water Piping: 30 psig at 150 deg F.
5. Blowdown-Drain Piping: Equal to pressure of the piping system to which it is attached.
6. Air-Vent and Vacuum-Breaker Piping: Equal to pressure of the piping system to which it is attached.
7. Safety-Valve-Inlet and -Outlet Piping: Equal to pressure of the piping system to which it is attached.

2.2 VALVES

A. Gate, Globe, Check, Ball Valves: Comply with requirements specified in Section 23 05 23.11 "Globe Valves for HVAC Piping," Section 23 05 23.12 "Ball Valves for HVAC Piping," Section 23 05 23.14 "Check Valves for HVAC Piping," and Section 23 05 23.15 "Gate Valves for HVAC Piping."

B. Stop-Check Valves:

1. Body and Bonnet: Malleable iron.
2. End Connections: Flanged.
3. Disc: Cylindrical with removable liner and machined seat.
5. Operator: Outside screw and yoke with cast-iron handwheel.
7. Pressure Class: 250.

2.3 STRAINERS

A. Y-Pattern Strainers:

1. Body: ASTM A 126, Class B cast iron, with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for strainers NPS 2 and smaller; flanged ends for strainers NPS 2-1/2 and larger.
3. Strainer Screen: Stainless-steel, 60-mesh strainer, or perforated stainless-steel basket.
4. Tapped blowoff plug.
5. CWP Rating: 250-psig working steam pressure.

B. Basket Strainers:

1. Body: ASTM A 126, Class B cast iron, with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for strainers NPS 2 and smaller; flanged ends for strainers NPS 2-1/2 and larger.
3. Strainer Screen: Stainless-steel, 20 mesh strainer, and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 250-psig working steam pressure.

2.4 FLASH TANKS

A. Shop or factory fabricated of welded steel according to ASME Boiler and Pressure Vessel Code, for 150-psig rating; and bearing ASME label. Fabricate with tappings for low-pressure steam and condensate outlets, high-pressure condensate inlet, air vent, safety valve, and legs.

2.5 SAFETY VALVES

A. Bronze or Brass Safety Valves: ASME labeled.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Apollo Valves; Conbraco Industries, Inc.
      b. Armstrong International, Inc.
      c. Kunkle Valve.
      d. Spirax Sarco, Inc.
      e. Watts; a Watts Water Technologies company.
   2. Disc Material: Forged copper alloy.
   3. End Connections: Threaded inlet and outlet.
   4. Spring: Fully enclosed steel spring with adjustable pressure range and positive shutoff, factory set and sealed.
   5. Pressure Class: 250.
   6. Drip-Pan Elbow: Cast iron and having threaded inlet and outlet with threads complying with ASME B1.20.1.
   7. Size and Capacity: As required for equipment according to ASME Boiler and Pressure Vessel Code.

   1. Disc Material: Forged copper alloy with bronze nozzle.
   2. End Connections: Raised-face flanged inlet and threaded or flanged outlet connections.
   3. Spring: Fully enclosed cadmium-plated steel spring with adjustable pressure range and positive shutoff, factory set and sealed.
   4. Pressure Class: 250.
   5. Drip-Pan Elbow: Cast iron and having threaded inlet, outlet, and drain, with threads complying with ASME B1.20.1.
   6. Exhaust Head: Cast iron and having threaded inlet and drain, with threads complying with ASME B1.20.1.
   7. Size and Capacity: As required for equipment according to ASME Boiler and Pressure Vessel Code.

2.6 PRESSURE-REDUCING VALVES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Fisher Model 92B (No alternates accepted)
B. ASME labeled.

C. Size, Capacity, and Pressure Rating: Factory set for inlet and outlet pressures indicated.

D. Description: Pilot-actuated, diaphragm type, with adjustable pressure range and positive shutoff.

E. Body: Cast iron.

F. End Connections: Threaded connections for valves NPS 2 and smaller and flanged connections for valves NPS 2-1/2 and larger.

G. Trim: Hardened stainless steel.

H. Head and Seat: Replaceable, main head stem guide fitted with flushing and pressure-arresting device cover over pilot diaphragm.


J. Capacities and Characteristics:

1. Steam Flow Rate: See Drawings.
2. Inlet Pressure: 45 psig.
3. Outlet Set Pressure: 7 psig.

2.7 STEAM TRAPS

A. Thermostatic Traps:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   b. Hoffman Specialty.
   c. Spirax Sarco, Inc.

2. Body: Bronze angle-pattern body with integral union tailpiece and screw-in cap.

3. Trap Type: Balanced-pressure.
4. Bellows: Stainless steel or monel.
5. Head and Seat: Replaceable, hardened stainless steel.
6. Pressure Class: 125.

B. Thermodynamic Traps:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   b. Hoffman Specialty.
   c. Spirax Sarco, Inc.

4. Disc and Seat: Stainless steel.
5. Maximum Operating Pressure: 600 psig.

C. Float and Thermostatic Traps:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   b. Hoffman Specialty.
   c. Spirax Sarco, Inc.
2. Body and Bolted Cap: ASTM A 126, cast iron.
6. Trap Type: Balanced pressure.
7. Thermostatic Bellows: Stainless steel or monel.
8. Thermostatic air vent capable of withstanding 45 deg F of superheat and resisting water hammer without sustaining damage.

D. Inverted Bucket Traps:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   b. Hoffman Specialty.
   c. Spirax Sarco, Inc.
2. Body and Cap: Cast iron.
7. Strainer: Integral stainless-steel inlet strainer within the trap body.

2.8 THERMOSTATIC AIR VENTS AND VACUUM BREAKERS

A. Thermostatic Air Vents:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
b. Hoffman Specialty.
c. Spirax Sarco, Inc.

2. Body: Cast iron, bronze, or stainless steel.


5. Thermostatic Element: Phosphor bronze bellows in a stainless-steel cage.


7. Maximum Temperature Rating: 350 deg F.

B. Vacuum Breakers:

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

   b. Hoffman Specialty.
   c. Spirax Sarco, Inc.

2. Body: Cast iron, bronze, or stainless steel.


5. O-Ring Seal: EPR.


7. Maximum Temperature Rating: 350 deg F.

2.9 FLEXIBLE CONNECTORS

A. Stainless-Steel Bellows, Flexible Connectors:

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

   a. Duraflex, Inc.
   b. Flexicraft Industries.
   c. Hyspan Precision Products, Inc.
   d. Mason Industries, Inc.
   e. Metraflex Company (The).
   f. Twin City Hose, Inc.


3. End Connections: Threaded or flanged to match equipment connected.


5. CWP Rating: 150 psig.

6. Maximum Operating Temperature: 250 deg F.

2.10 CONDENSATE METERS

A. Provide magnetic flow meter for steam condensate.
B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Badger M2000 (no alternates)
C. Body: Cast iron, bronze, or brass.
D. Connections: Threaded for NPS 2 and smaller and flanged for NPS 2-1/2.
E. Totalizer: Meters shall have a microprocessor to display flow, flow rate, time, and date; alarms for high and low flow rate, pressure, and temperature.
   1. Computer shall have 4- to 20-mA or 2- to 10-V output for temperature, pressure, and contact closure for flow increments.
   2. Independent timers to store four peak flow rates and total flow.
   3. Interface compatible with “Square D” Ion Metering System.
   5. Provide relay to convert wet contact to dry contact
F. Pressure Rating: Atmospheric.
G. Maximum Temperature Rating: 250 deg F.

PART 3 - EXECUTION

3.1 VALVE APPLICATIONS
   A. Install shutoff duty valves at branch connections to steam supply mains, at steam supply connections to equipment, and at the outlet of steam traps.
   B. Install safety valves on pressure-reducing stations and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install safety-valve discharge piping, without valves, to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, for installation requirements.

3.2 PIPING INSTALLATION
   A. Install piping to permit valve servicing.
   B. Install drains, consisting of a tee fitting, NPS 3/4 full port-ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.
   C. Install valves according to Section 23 05 23.11 "Globe Valves for HVAC Piping," Section 23 05 23.12 "Ball Valves for HVAC Piping," Section 23 05 23.14 "Check Valves for HVAC Piping," and Section 23 05 23.15 "Gate Valves for HVAC Piping."
   D. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.
   E. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.
F. Install shutoff valve immediately upstream of each dielectric fitting.

G. Install strainers on supply side of control valves, pressure-reducing valves, traps, and elsewhere as indicated. Install NPS 3/4 nipple and full port ball valve in blowdown connection of strainers NPS 2 and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2.

H. Flash Tank:
   1. Pitch condensate piping down toward flash tank.
   2. If more than one condensate pipe discharges into flash tank, install a check valve in each line.
   3. Install thermostatic air vent at tank top.
   4. Install safety valve at tank top.
   5. Install full-port ball valve, and swing check valve on condensate outlet.
   6. Install inverted bucket or float and thermostatic trap at low-pressure condensate outlet, sized for three times the calculated heat load.
   7. Install pressure gage on low-pressure steam outlet according to Section 23 05 19 "Meters and Gages for HVAC Piping."

3.3 STEAM-TRAP INSTALLATION

A. Install steam traps in accessible locations as close as possible to connected equipment.

B. Install full-port ball valve, strainer, and union upstream from trap; install union, check valve, and full-port ball valve downstream from trap unless otherwise indicated.

3.4 PRESSURE-REDUCING VALVE INSTALLATION

A. Install pressure-reducing valves in accessible location for maintenance and inspection.

B. Install bypass piping around pressure-reducing valves, with globe valve equal in size to area of pressure-reducing valve seat ring, unless otherwise indicated.

C. Install gate valves on both sides of pressure-reducing valves.

D. Install unions or flanges on both sides of pressure-reducing valves having threaded- or flanged-end connections, respectively.

E. Install pressure gages on low-pressure side of pressure-reducing valves after the bypass connection according to Section 23 05 19 "Meters and Gages for HVAC Piping."

F. Install strainers upstream for pressure-reducing valve.

G. Install safety valve downstream from pressure-reducing valve station.

3.5 STEAM OR CONDENSATE METER INSTALLATION

A. Install meters with lengths of straight pipe upstream and downstream according to steam meter manufacturer's written instructions.

B. Provide data acquisition wiring.
3.6 SAFETY VALVE INSTALLATION

A. Install safety valves according to ASME B31.9, "Building Services Piping."

B. Pipe safety-valve discharge without valves to atmosphere outside the building.

C. Install drip-pan elbow fitting adjacent to safety valve and pipe drain connection to nearest floor drain.

D. Install exhaust head with drain to waste, on vents equal to or larger than NPS 2-1/2.

3.7 TERMINAL EQUIPMENT CONNECTIONS

A. Install traps and control valves in accessible locations close to connected equipment.

B. Install bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.

C. Install vacuum breakers downstream from control valve, close to coil inlet connection.

END OF SECTION 23 22 16
SECTION 23 22 23 - STEAM CONDENSATE PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes steam condensate pumps.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.
B. Shop Drawings: For each pump.
   1. Show pump layout and connections.
   2. Include setting drawings with templates for installing foundation and anchor bolts and other anchorages.
   3. Include diagrams for power, signal, and control wiring.

1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 SINGLE-STAGE, CENTRIFUGAL PUMPS WITH FLOOR-MOUNTED RECEIVER

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Armstrong Fluid Handling.
   2. ITT Corporation.
   4. Spirax Sarco, Inc.

B. Description: Factory-fabricated, packaged, electric-driven pumps; with receiver, pumps, controls, and accessories suitable for operation with steam condensate.
   1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
   2. ASME Compliance: Fabricate and label steam condensate receivers to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

C. Configuration: Duplex floor-mounted pump with receiver and float switches; rated to pump 200 deg F steam condensate.

D. Receiver:
1. Floor mounted.
2. Close-grained cast iron.
3. Externally adjustable float switches.
4. Flanges for pump mounting.
5. Water-level gage and dial thermometer.
6. Liquid filled pressure gage with pressure snubber at each pump discharge.
7. Bronze fitting isolation valve between pump and receiver.
8. Lifting eyebolts.
9. Inlet vent and an overflow.

E. Pumps:

1. Centrifugal, close coupled, vertical design.
2. Low NSPH.
3. Permanently aligned.
4. Bronze fitted.
5. Replaceable bronze case ring.
6. Mechanical seals rated at 250 deg F.
7. Mounted on receiver flange.

F. Motor:

1. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 23 05 13 "Common Motor Requirements for HVAC Equipment."
2. Enclosure: TEFC.
5. Efficiency: Premium efficient.
6. NEMA Design: A.
7. Service Factor: 1.1.

G. Control Panel:

1. Factory wired between pumps and float switches, for single external electrical connection.
2. Provide fused, control-power transformer if voltage exceeds 230 V ac.
3. NEMA 250, Type 3 enclosure with hinged door and grounding lug, mounted on pump.
4. Motor controller for each pump.
5. Provide dual float switches. One for normal pump operation, one for high water alarm, second pump operation.
6. Mechanical pump alternator to operate pumps in lead-lag sequence and allow both pumps to operate on receiver high level.
7. Manual lead-lag control to override electrical pump alternator and manually select the lead pump.
8. Momentary-contact "TEST" push button on cover for each pump.
10. Disconnect switch.
11. Provide output to DDC system for each high water alarm.

H. Capacities and Characteristics:

1. See Drawings.
PART 3 - EXECUTION

3.1 INSTALLATION

A. Install pumps according to HI 1.1-1.2, HI 1.3, and HI 1.4.

B. Install pumps to provide access for periodic maintenance including removing motors, impellers, couplings, and accessories.

C. Support pumps and piping separately so piping is not supported by pumps.

D. Install thermometers and pressure gages.

E. Equipment Mounting:
   1. Install pumps on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 03 30 53 "Miscellaneous Cast-in-Place Concrete."
   2. Comply with requirements for vibration isolation and seismic control devices specified in Section 22 05 48 "Vibration and Seismic Controls for Plumbing Piping and Equipment."
   3. Comply with requirements for vibration isolation devices specified in Section 22 05 48.13 "Vibration Controls for Plumbing Piping and Equipment."

3.2 CONNECTIONS

A. Comply with requirements for piping specified in Section 23 22 13 "Steam and Condensate Heating Piping" and Section 23 22 16 "Steam and Condensate Piping Specialties."

B. Where installing piping adjacent to machine, allow space for service and maintenance.

C. Install a globe and check valve and pressure gage before inlet of each pump and a gate and check valve at pump outlet.

D. Pipe drain to nearest floor drain for overflow and drain piping connections.

E. Install full-size vent piping to outdoors, terminating in 180-degree elbow at point above highest steam system connection or as indicated.

F. Ground equipment according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."

G. Connect wiring according to Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

END OF SECTION 23 22 23
SECTION 23 25 13 - WATER TREATMENT FOR CLOSED-LOOP HYDRONIC SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes the following water treatment for closed-loop hydronic systems:

2. Chemicals.

1.2 ACTION SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, and furnished specialties and accessories for each type of product.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Ampion Corp.
2. Anderson Chemical Company.
3. Aqua-Chem, Inc.
5. Boland Trane Services.
6. Cascade Water Services, Inc.
7. Earthwise Environmental Inc.
10. Metro Group, Inc. (The).
11. Nalco; an Ecolab company.
12. Sonitec-Vortisand inc
13. Watcon, Inc.
14. Water Services Inc.
2.2 PERFORMANCE REQUIREMENTS

A. Closed hydronic systems shall have the following water qualities:

1. pH: Maintain a value within 9.0 to 10.5.
2. "P" Alkalinity: Maintain a value within 100 to 500 ppm.
3. Boron: Maintain a value within 100 to 200 ppm.
4. Chemical Oxygen Demand: Maintain a maximum value of 100 ppm.
5. Soluble Copper: Maintain a maximum value of 0.20 ppm.
6. TSS: Maintain a maximum value of 10 ppm.
9. Microbiological Limits:
   a. Total Aerobic Plate Count: Maintain a maximum value of 1000 organisms/mL.
   b. Total Anaerobic Plate Count: Maintain a maximum value of 100 organisms/mL.
   c. Nitrate Reducers: Maintain a maximum value of 100 organisms/mL.
   d. Sulfate Reducers: Maintain a maximum value of zero organisms/mL.
   e. Iron Bacteria: Maintain a maximum value of zero organisms/mL.

2.3 MANUAL CHEMICAL-FEED EQUIPMENT

A. Bypass Feeders: Steel, with corrosion-resistant exterior coating, minimum 3-1/2-inch fill opening in the top, and NPS 3/4 bottom inlet and top side outlet. Quarter turn or threaded fill cap with gasket seal and diaphragm to lock the top on the feeder when exposed to system pressure in the vessel.

1. Capacity: 2 gal..

2.4 AUTOMATIC CHEMICAL-FEED EQUIPMENT

A. Water Meter:

1. AWWA C700, oscillating-piston, magnetic-drive, totalization meter.
2. Body: Bronze.
5. Registration: Gallons or cubic feet.
7. Controls: Flow-control switch with normally open contacts; rated for maximum 10 A, 250-V ac; and that will close at adjustable increments of total flow.
8. 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. Chemical Solution Tanks:

1. Chemical-resistant reservoirs fabricated from high-density opaque polyethylene with minimum 110 percent containment vessel.
2. Molded cover with recess for mounting pump.
3. Capacity: 50 gal..

C. Chemical Solution Injection Pumps:
1. Self-priming, positive displacement; rated for intended chemical with minimum 25 percent safety factor for design pressure and temperature.
2. Adjustable flow rate.
3. Metal and thermoplastic construction.
5. Fully enclosed, continuous-duty, single-phase motor. Comply with requirements in Section 23 05 13 "Common Motor Requirements for HVAC Equipment."
6. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. Chemical Solution Tubing: Polyethylene tubing with compression fittings and joints except ASTM A 269, Type 304, stainless steel for steam boiler injection assemblies.

E. Injection Assembly:
   1. Quill: Minimum NPS 1/2 with insertion length sufficient to discharge into at least 25 percent of pipe diameter.
   2. Ball Valve: Three-piece, stainless steel; selected to fit quill.
   3. Packing Gland: Mechanical seal on quill of sufficient length to allow quill removal during system operation.
   4. Assembly Pressure/Temperature Rating: Minimum 600 psig at 200 deg F.

2.5 CHEMICALS

A. Chemicals shall be as recommended by water-treatment system manufacturer that are compatible with piping system components and connected equipment and that can attain water quality specified in "Performance Requirements" Article.

PART 3 - EXECUTION

3.1 WATER ANALYSIS

A. Perform an analysis of supply water to determine quality of water available at Project site.

3.2 INSTALLATION

A. Install chemical application equipment on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units so controls and devices that require servicing are accessible. Anchor chemical tanks and floor-mounting accessories to substrate.

B. Install seismic restraints for equipment and floor-mounting accessories and anchor to building structure. Comply with requirements in Section 23 05 48 "Vibration and Seismic Controls for HVAC" for seismic restraints.

C. Install water testing equipment on wall near water chemical application equipment.

D. Install interconnecting control wiring for chemical treatment controls and sensors.

E. Mount sensors and injectors in piping circuits.
F. Bypass Feeders: Install in closed hydronic systems, including hot-water heating and heat pump loop, and equipped with the following:

1. Install bypass feeder in a bypass circuit around circulating pumps unless otherwise indicated on Drawings.
2. Install water meter in makeup-water supply.
3. Install test-coupon assembly in bypass circuit around circulating pumps unless otherwise indicated on Drawings.
4. Install a gate or full-port ball isolation valves on inlet, outlet, and drain below the feeder inlet.
5. Install a swing check on the inlet after the isolation valve.

G. Where installing piping adjacent to equipment, allow space for service and maintenance.

H. Make piping connections between HVAC water-treatment equipment and dissimilar-metal piping with dielectric fittings. Comply with requirements in Section 23 21 16 "Hydronic Piping Specialties"

I. Install shutoff valves on HVAC water-treatment equipment inlet and outlet. Metal general-duty valves are specified in Section 23 05 23.11 "Globe Valves for HVAC Piping," Section 23 05 23.12 "Ball Valves for HVAC Piping," and Section 23 05 23.15 "Gate Valves for HVAC Piping."

J. Comply with requirements in Section 22 11 19 "Domestic Water Piping Specialties" for backflow preventers required in makeup-water connections to potable-water systems.

K. Confirm applicable electrical requirements in electrical Sections for connecting electrical equipment.

L. Ground equipment according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."

M. Connect wiring according to Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

3.3 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Inspect field-assembled components and equipment installation, including piping and electrical connections.
2. Inspect piping and equipment to determine that systems and equipment have been cleaned, flushed, and filled with water, and are fully operational before introducing chemicals for water-treatment system.
3. Place HVAC water-treatment system into operation and calibrate controls during the preliminary phase of hydronic systems’ startup procedures.
4. Do not enclose, cover, or put piping into operation until it is tested and satisfactory test results are achieved.
5. Test for leaks and defects. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
6. Leave uncovered and unconcealed new, altered, extended, and replaced water piping until it has been tested and approved. Expose work that has been covered or concealed before it has been tested and approved.
7. Cap and subject piping to static water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow test pressure to stand for four hours. Leaks and loss in test pressure constitute defects.
8. Repair leaks and defects with new materials and retest piping until no leaks exist.

B. Equipment will be considered defective if it does not pass tests and inspections.
C. Prepare test and inspection reports.

END OF SECTION 23 25 13
SECTION 23 31 13 - METAL DUCTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Rectangular ducts and fittings.
2. Round ducts and fittings.
4. Sealants and gaskets.
5. Hangers and supports.

B. Related Sections:

1. Section 23 05 93 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing requirements for metal ducts.
2. Section 23 31 16 "Nonmetal Ducts" for fibrous-glass ducts, thermoset fiber-reinforced plastic ducts, thermoplastic ducts, PVC ducts, and concrete ducts.
3. Section 23 31 19 "HVAC Casings" for factory- and field-fabricated casings for mechanical equipment.
4. Section 23 33 00 "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.2 PERFORMANCE REQUIREMENTS

A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and performance requirements and design criteria indicated in "Duct Schedule" Article.

B. Structural Performance: Duct hangers and supports and seismic restraints shall withstand the effects of gravity and seismic loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems."

1. Seismic Hazard Level A: Seismic force to weight ratio, 0.48.
2. Seismic Hazard Level B: Seismic force to weight ratio, 0.30.
3. Seismic Hazard Level C: Seismic force to weight ratio, 0.15.

C. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.
B. LEED Submittals:

1. Product Data for Prerequisite IEQ 1: Documentation indicating that duct systems comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."
2. Product Data for Prerequisite EA 2: Documentation indicating that duct systems comply with ASHRAE/IESNA 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."
3. Duct-Cleaning Test Report for Prerequisite IEQ 1: Documentation of work performed for compliance with ASHRAE 62.1, Section 7.2.4 - "Ventilation System Start-up."
4. Product Data for Credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content.
5. Laboratory Test Reports for Credit IEQ 4: For adhesives and sealants, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. Shop Drawings:

1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
2. Factory- and shop-fabricated ducts and fittings.
3. Duct layout indicating sizes, configuration, and static-pressure classes.
4. Elevation of top of ducts.
5. Dimensions of main duct runs from building grid lines.
6. Fittings.
7. Reinforcement and spacing.
8. Seam and joint construction.
9. Penetrations through fire-rated and other partitions.
10. Equipment installation based on equipment being used on Project.
11. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
12. Hangers and supports, including methods for duct and building attachment, seismic restraints, and vibration isolation.

D. Delegated-Design Submittal:

1. Sheet metal thicknesses.
2. Joint and seam construction and sealing.
3. Reinforcement details and spacing.
4. Materials, fabrication, assembly, and spacing of hangers and supports.
5. Design Calculations: Calculations, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation for selecting seismic restraints.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Duct installation in congested spaces, indicating coordination with general construction, building components, and other building services. Indicate proposed changes to duct layout.
2. Suspended ceiling components.
3. Structural members to which duct will be attached.
4. Size and location of initial access modules for acoustical tile.
5. Penetrations of smoke barriers and fire-rated construction.
6. Items penetrating finished ceiling including the following:
a. Lighting fixtures.
b. Air outlets and inlets.
c. Speakers.
d. Sprinklers.
e. Access panels.
f. Perimeter moldings.

B. Welding certificates.

1.5 QUALITY ASSURANCE


B. Welding Qualifications: Qualify procedures and personnel according to the following:

C. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."

D. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

PART 2 - PRODUCTS

2.1 RECTANGULAR DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
2.2 ROUND DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.

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

   a. Ductmate Industries, Inc.
   b. Lindab Inc.
   c. McGill Airflow LLC
   d. SEMCO LLC
   e. Sheet Metal Connectors, Inc.
   f. Spiral Manufacturing Company

B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Fabricate round ducts larger Than 90 inches in diameter with butt-welded longitudinal seams.

D. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.3 SHEET METAL MATERIALS

A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.

1. Galvanized Coating Designation: G60.
2. Finishes for Surfaces Exposed to View: Mill phosphatized.

C. Carbon-Steel Sheets: Comply with ASTM A 1008/A 1008M, with oiled, matte finish for exposed ducts.

D. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304 or 316, as indicated in the "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in the "Duct Schedule" Article.
E. 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.

F. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
   1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.

G. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.4 SEALANT AND GASKETS

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.

B. Two-Part Tape Sealing System:
   1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
   2. Tape Width: 4 inches.
   5. Mold and mildew resistant.
   6. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
   7. Service: Indoor and outdoor.
   8. Service Temperature: Minus 40 to plus 200 deg F.
   9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.
   10. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   11. Sealant shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. Water-Based Joint and Seam Sealant:
   1. Application Method: Brush on.
   2. Solids Content: Minimum 65 percent.
   5. Mold and mildew resistant.
   6. VOC: Maximum 75 g/L (less water).
   7. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
   8. Service: Indoor or outdoor.
   9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

D. Flanged Joint Sealant: Comply with ASTM C 920.
2. Type: S.
3. Grade: NS.
5. Use: O.
6. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealant shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

E. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

F. Round Duct Joint O-Ring Seals:
1. Seal shall provide maximum 3 cfm/100 sq. ft. at 1-inch wg and shall be rated for 10-inch wg static-pressure class, positive or negative.
2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.5 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.

B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."

D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.

E. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A 492.

F. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

G. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

H. Trapeze and Riser Supports:
3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

2.6 SEISMIC-RESTRAINT DEVICES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. B-line, and Eaton business
2. Ductmate Industries, Inc.
3. Hilti, Inc.
5. Loos & Co.
6. Mason Industries, Inc.
7. TOLCO
8. Unistrut

B. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an agency acceptable to authorities having jurisdiction.

1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.

C. Channel Support System: Shop- or field-fabricated support assembly made of slotted steel channels rated in tension, compression, and torsion forces and with accessories for attachment to braced component at one end and to building structure at the other end. Include matching components and corrosion-resistant coating.

D. Restraint Cables: ASTM A 492, stainless-steel cables with end connections made of cadmium-plated steel assemblies with brackets, swivel, and bolts designed for restraining cable service; and with an automatic-locking and clamping device or double-cable clips.

E. Hanger Rod Stiffener: Reinforcing steel angle clamped to hanger rod.

F. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.

B. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.

C. Install round ducts in maximum practical lengths.

D. Install ducts with fewest possible joints.

E. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

F. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
H. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.

I. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

J. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.

K. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Section 23 33 00 "Air Duct Accessories" for fire and smoke dampers.


3.2 INSTALLATION OF EXPOSED DUCTWORK

A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.

B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.

C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.

D. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.

E. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.3 DUCT SEALING

A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

B. Seal ducts to the following seal classes according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible":

1. Comply with SMACNA’s "HVAC Duct Construction Standards - Metal and Flexible."
2. Outdoor, Supply-Air Ducts: Seal Class A.
3. Outdoor, Exhaust Ducts: Seal Class C.
4. Outdoor, Return-Air Ducts: Seal Class C.
5. Unconditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class B.
6. Unconditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class A.
7. Unconditioned Space, Exhaust Ducts: Seal Class C.
8. Unconditioned Space, Return-Air Ducts: Seal Class B.
9. Conditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class C.
10. Conditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class B.
11. Conditioned Space, Exhaust Ducts: Seal Class B.
12. Conditioned Space, Return-Air Ducts: Seal Class C.

3.4 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA’s "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Where practical, install concrete inserts before placing concrete.
2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
5. Do not use powder-actuated concrete fasteners for seismic restraints.

C. Hanger Spacing: Comply with SMACNA’s "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.

D. Hangers Exposed to View: Threaded rod and angle or channel supports.

E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet.

F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.5 SEISMIC-RESTRAINT-DEVICE INSTALLATION

A. Install ducts with hangers and braces designed to support the duct and to restrain against seismic forces required by applicable building codes. Comply with SMACNA’s "Seismic Restraint Manual: Guidelines for Mechanical Systems."

1. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.
2. Brace a change of direction longer than 12 feet.

B. Select seismic-restraint devices with capacities adequate to carry present and future static and seismic loads.

C. Install cables so they do not bend across edges of adjacent equipment or building structure.

D. Install cable restraints on ducts that are suspended with vibration isolators.

E. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction.
F. Attachment to Structure: If specific attachment is not indicated, anchor bracing and restraints to structure, to flanges of beams, to upper truss chords of bar joists, or to concrete members.

G. Drilling for and Setting Anchors:
   1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcement or embedded items during drilling. Notify the Architect if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
   2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
   3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
   4. Set anchors to manufacturer's recommended torque, using a torque wrench.
   5. Install zinc-coated steel anchors for interior applications and stainless-steel anchors for applications exposed to weather.

3.6 CONNECTIONS
A. Make connections to equipment with flexible connectors complying with Section 23 33 00 "Air Duct Accessories."
B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.7 START UP
A. Air Balance: Comply with requirements in Section 23 05 93 "Testing, Adjusting, and Balancing for HVAC."

3.8 DUCT SCHEDULE
A. Fabricate ducts with galvanized sheet steel except as otherwise indicated and as follows:

B. Supply Ducts:
   1. Ducts Connected to Fan Coil Units, Heat Pumps, and Terminal Units:
      a. Pressure Class: Positive 1-inch wg.
      b. Minimum SMACNA Seal Class: C.
      c. SMACNA Leakage Class for Rectangular: 12.
      d. SMACNA Leakage Class for Round and Flat Oval: 12.
   2. Ducts Connected to Constant-Volume Air-Handling Units AHU-1:
      a. Pressure Class: Positive 2-inch wg.
      b. Minimum SMACNA Seal Class: B.
c. SMACNA Leakage Class for Rectangular: 12.
d. SMACNA Leakage Class for Round and Flat Oval: 6.

3. Ducts Connected to Variable-Air-Volume Air-Handling Units DOAS-1/ECON-1:
   a. Pressure Class: Positive 4-inch wg.
   b. Minimum SMACNA Seal Class: A.
   c. SMACNA Leakage Class for Rectangular: 3.
   d. SMACNA Leakage Class for Round and Flat Oval: 3.

C. Return Ducts:
   1. Ducts Connected to Fan Coil Units, Heat Pumps, and Terminal Units:
      a. Pressure Class: Positive or negative 1-inch wg.
      b. Minimum SMACNA Seal Class: C.
      c. SMACNA Leakage Class for Rectangular: 12.
      d. SMACNA Leakage Class for Round and Flat Oval: 12.
   2. Ducts Connected to Air-Handling Units AHU-1:
      a. Pressure Class: Positive or negative 2-inch wg.
      b. Minimum SMACNA Seal Class: A.
      c. SMACNA Leakage Class for Rectangular: 6.
      d. SMACNA Leakage Class for Round and Flat Oval: 6.

D. Exhaust Ducts:
   1. Ducts Connected to Fans Exhausting (ASHRAE 62.1, Class 1 and 2) Air:
      a. Pressure Class: Negative 1-inch wg or 1" over scheduled fan static.
      b. Minimum SMACNA Seal Class: B if negative pressure, and A if positive pressure.
      c. SMACNA Leakage Class for Rectangular: 12.
      d. SMACNA Leakage Class for Round and Flat Oval: 12.
   2. Ducts Connected to Air-Handling Units DOAS-1:
      a. Pressure Class: Positive or negative 3-inch wg.
      b. Minimum SMACNA Seal Class: A if negative pressure, and A if positive pressure.
      c. SMACNA Leakage Class for Rectangular: 6.
      d. SMACNA Leakage Class for Round and Flat Oval: 3.

E. Outdoor-Air (Not Filtered, Heated, or Cooled) Ducts:
   1. Ducts Connected to Air-Handling Units AHU-1/DOAS-1:
      a. Pressure Class: Positive or negative 2-inch wg.
      b. Minimum SMACNA Seal Class: B.
      c. SMACNA Leakage Class for Rectangular: 12.
      d. SMACNA Leakage Class for Round and Flat Oval: 6.

F. Intermediate Reinforcement:
2. PVC-Coated Ducts:
   a. Exposed to Airstream: Match duct material.
   b. Not Exposed to Airstream: Match duct material.

3. Stainless-Steel Ducts:
   a. Exposed to Airstream: Match duct material.
   b. Not Exposed to Airstream: Match duct material.


G. Elbow Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."
   a. Velocity 1000 fpm or Lower:
      1) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.
      2) Mitered Type RE 4 without vanes.
   b. Velocity 1000 to 1500 fpm:
      1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.
      2) Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.
      3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
   c. Velocity 1500 fpm or Higher:
      1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
      2) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
      3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

2. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."
   a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
   b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
   c. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

3. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "Round Duct Elbows."
   a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.
1) Velocity 1000 fpm or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.

2) Velocity 1000 to 1500 fpm: 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.

3) Velocity 1500 fpm or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.

4) Radius-to Diameter Ratio: 1.5.

b. Round Elbows, 12 Inches and Smaller in Diameter: Stamped or pleated.

c. Round Elbows, 14 Inches and Larger in Diameter: Standing seam.

**H. Branch Configuration:**

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connection."

   a. Rectangular Main to Rectangular Branch: 45-degree entry.
   
   b. Rectangular Main to Round Branch: Spin in.

2. Round: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees." Saddle taps are permitted in existing duct.

   a. Velocity 1000 fpm or Lower: 90-degree tap.
   
   b. Velocity 1000 to 1500 fpm: Conical tap.
   
   c. Velocity 1500 fpm or Higher: 45-degree lateral.

END OF SECTION 23 31 13
SECTION 23 33 00 - AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Backdraft and pressure relief dampers.
3. Control dampers.
4. Fire dampers.
5. Smoke dampers.
6. Flange connectors.
7. Turning vanes.
8. Duct-mounted access doors.
10. Flexible ducts.
11. Duct accessory hardware.

B. Related Requirements:

1. Section 23 37 23 "HVAC Gravity Ventilators" for roof-mounted ventilator caps.
2. Section 28 31 11 "Digital, Addressable Fire-Alarm System" for duct-mounted fire and smoke detectors.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. LEED Submittals:

1. Product Data for Prerequisite IEQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."
2. Product Data for Prerequisite EA 2: Documentation indicating that duct insulation R-values comply with tables in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air Conditioning."

C. Shop Drawings: For duct accessories. Include plans, elevations, sections, details and attachments to other work.

1. Detail duct accessories fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:

   a. Special fittings.
   c. Control-damper installations.
d. Fire-damper and smoke-damper installations, including sleeves; and duct-mounted access doors.
e. Wiring Diagrams: For power, signal, and control wiring.

1.3 CLOSEOUT SUBMITTALS
A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTION
B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

2.2 MATERIALS
A. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
   1. Galvanized Coating Designation: G60.
   2. Exposed-Surface Finish: Mill phosphatized.
B. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304, and having a No. 2 finish for concealed ducts No. 2 finish for exposed ducts.
C. Aluminum Sheets: Comply with ASTM B 209, Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.
D. Extruded Aluminum: Comply with ASTM B 221, Alloy 6063, Temper T6.
E. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.
F. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.3 BACKDRAFT AND PRESSURE RELIEF DAMPERS
A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. American Warming and Ventilating.
   2. Cesco Products.
5. Pottorff.
6. Ruskin Company.

B. Description: Gravity balanced.


D. Maximum System Pressure: 3-inch wg.

E. Frame: Hat-shaped, 0.094-inch- thick, galvanized sheet steel 0.063-inch- thick extruded aluminum 0.05-inch- thick stainless steel, with welded corners or mechanically attached and mounting flange.

F. Blades: Multiple single-piece blades, off-center pivoted, maximum 6-inch width, 0.025-inch- thick, roll-formed aluminum with sealed edges.

G. Blade Action: Parallel.

H. Blade Seals: Extruded vinyl, mechanically locked.

I. Blade Axles:
   1. Material: Galvanized steel or Stainless steel.
   2. Diameter: 0.20 inch.

J. Tie Bars and Brackets: Galvanized steel.

K. Return Spring: Adjustable tension.

L. Bearings: Steel ball or synthetic pivot bushings.

M. Accessories:
   1. Adjustment device to permit setting for varying differential static pressure.
   2. Counterweights and spring-assist kits for vertical airflow installations.
   3. Electric actuators.
   4. Chain pulls.
   5. Screen Mounting: Front mounted in sleeve.
      a. Sleeve Thickness: 20 gage minimum.
      b. Sleeve Length: 6 inches minimum.
   6. Screen Mounting: Rear mounted.
   7. Screen Material: Galvanized steel.
   8. Screen Type: Bird.
   9. 90-degree stops.

2.4 MANUAL VOLUME DAMPERS

A. Standard, Steel, Manual Volume Dampers:

   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. American Warming and Ventilating; a Mestek Architectural Group company.
b. Flexmaster U.S.A., Inc.
c. McGill AirFlow LLC.
d. Nailor Industries Inc.
e. Pottorff.
f. Ruskin Company.

2. Standard leakage rating.
3. Suitable for horizontal or vertical applications.
4. Dampers for low pressure rectangular ductwork

a. In ducts 12” in the larger dimension:
   1) Frames:
      a) Frame: Hat-shaped, 0.064-inch- thick (16 gauge), galvanized sheet steel.
      b) Mitered and welded corners.
      c) Flanges for attaching to walls and flangeless frames for installing in ducts.

   2) Blades:
      a) Single blade.
      b) Galvanized-steel, 0.036 inch (20 gauge) thick.

b. In ducts over 12” in the larger dimension:
   1) Frames:
      a) Frame: Hat-shaped, 0.064-inch- thick (16 gauge), galvanized sheet steel.
      b) Mitered and welded corners.
      c) Flanges for attaching to walls and flangeless frames for installing in ducts.

   2) Blades:
      a) Multiple blade.
      b) Opposed-blade design.
      c) Galvanized-steel, 0.064 inch thick (16 gauge).

5. Dampers for low pressure round ductwork

a. In ducts 4”-12” in diameter:
   1) Frames:
      a) Frame: Steel channel frame, 0.036-inch-thick (20 gauge), galvanized sheet steel.
      b) Flanges for attaching to walls and flangeless frames for installing in ducts.

   2) Blades:
      a) Single blade.
      b) Galvanized-steel, 0.028 inch (22 gauge) thick.

b. In ducts 13”-18” in the larger dimension:
1) Frames:
   a) Frame: Steel channel frame, 0.036-inch-thick (20 gauge), galvanized sheet
      steel.
   b) Flanges for attaching to walls and flangeless frames for installing in ducts.

2) Blades:
   a) Single blade.
   b) Galvanized-steel, 0.036 inch (20 gauge) thick.
   c) In ducts 19”-24” in the larger dimension:
      1) Frames:
         a) Frame: Steel channel frame, 0.048-inch-thick (18 gauge), galvanized sheet
            steel.
         b) Flanges for attaching to walls and flangeless frames for installing in ducts.
      2) Blades:
         a) Single blade.
         b) Galvanized-steel, 0.064 inch (16 gauge) thick.

7. Bearings:
   a. Oil-impregnated bronze.
   b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of
      damper blades and bearings at both ends of operating shaft.

8. Tie Bars and Brackets: Galvanized steel.

B. Standard, Aluminum, Manual Volume Dampers:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the
      following:
      a. American Warming and Ventilating; a Mestek Architectural Group company.
      b. McGill AirFlow LLC.
      c. Nailor Industries Inc.
      d. Pottorff.
      e. Ruskin Company.

   2. Standard leakage rating.
   3. Suitable for horizontal or vertical applications.
   4. Frames: Hat-shaped, 0.10-inch-thick, aluminum sheet channels; frames with flanges for
      attaching to walls and flangeless frames for installing in ducts.
   5. Blades:
      a. Multiple or single blade.
      b. Parallel- or opposed-blade design.
      c. Stiffen damper blades for stability.
      d. Roll-Formed Aluminum Blades: 0.10-inch-thick aluminum sheet.
AIR DUCT ACCESSORIES

2.5 CONTROL DAMPERS

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

1. American Warming and Ventilating; a Mestek Architectural Group company.
2. Cesco Products; a division of MESTEK, Inc.
4. McGill AirFlow LLC.
5. Nailor Industries Inc.
6. Potterff.
7. Ruskin Company.

B. Frames:

1. Hat shaped.
2. 0.094-inch- thick, galvanized sheet steel.
3. Mitered and welded corners.

C. Blades:

1. Airfoil-shaped single piece
2. Multiple blade with maximum blade width of 6 inches.
3. Blades and seals to be ultra low leakage
4. Parallel- and opposed-blade design.
5. Aluminum T-6063
6. 0.0747-inch- thick dual skin.

Note: Extruded-Aluminum Blades: 0.050-inch- thick extruded aluminum.

7. Bearings:
   a. Oil-impregnated bronze.
   b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.

8. Tie Bars and Brackets: Aluminum.

C. Jackshaft:

1. Size: 0.5-inch diameter.
2. Material: Galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
3. Length and Number of Mountings: As required to connect linkage of each damper in multiple-damper assembly.

D. Damper Hardware:

2. Include center hole to suit damper operating-rod size.
3. Include elevated platform for insulated duct mounting.
D. Blade Axles: 1/2-inch- diameter; stainless steel; blade-linkage hardware of zinc-plated steel and brass; ends sealed against blade bearings.

1. Operating Temperature Range: From minus 40 to plus 200 deg F.

E. Bearings:

1. Molded synthetic.
2. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
3. Thrust bearings at each end of every blade.

2.6 FIRE DAMPERS

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

1. American Warming and Ventilating.
2. Arrow United Industries.
3. Cesco Products.
5. Nailor Industries Inc.
6. Pottorff.
7. Prefco.
8. Ruskin Company.
9. Vent Products Co., Inc.
10. Ward Industries.

B. Type: Dynamic; rated and labeled according to UL 555 by an NRTL.

C. Closing rating in ducts up to 4-inch wg static pressure class and minimum 2000-fpm velocity.

D. Fire Rating: 1-1/2 and 3 hours.

E. Frame: Curtain type with blades outside airstream except when located behind grille where blades may be inside airstream; fabricated with roll-formed, 0.034-inch- thick galvanized steel; with mitered and interlocking corners.

F. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel.

1. Minimum Thickness: 0.138 inch or 0.39 inch thick, as indicated, and of length to suit application.
2. Exception: Omit sleeve where damper-frame width permits direct attachment of perimeter mounting angles on each side of wall or floor; thickness of damper frame must comply with sleeve requirements.

G. Mounting Orientation: Vertical or horizontal as indicated.

H. Blades: Roll-formed, interlocking, 0.024-inch- thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch- thick, galvanized-steel blade connectors.

I. Horizontal Dampers: Include blade lock and stainless-steel closure spring.

J. Heat-Responsive Device: Electric, resettable link and switch package, factory installed, 165 deg F and 212 deg F rated.
2.7 SMOKE DAMPERS

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

1. Aire Technologies.
2. American Warming and Ventilating.
3. Cesco Products.
5. Nailor Industries Inc.
6. Pottorff.
7. Ruskin Company.

B. General Requirements: Label according to UL 555S by an NRTL.

C. Smoke Detector: Integral, factory wired for single-point connection.

D. Frame: Hat-shaped, 0.094-inch-thick, galvanized sheet steel, with interlocking, gusseted or mechanically attached corners and mounting flange.

E. Blades: Roll-formed, horizontal, interlocking, 0.034-inch-thick, galvanized sheet steel.

F. Leakage: Class II.

G. Rated pressure and velocity to exceed design airflow conditions.

H. Mounting Sleeve: Factory-installed, 0.05-inch-thick, galvanized sheet steel; length to suit wall or floor application.

I. Damper Motors: two-position action.

J. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 23 05 13 "Common Motor Requirements for HVAC Equipment."

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Section 23 09 23 "Direct Digital Control (DDC) System for HVAC"
3. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
4. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf and breakaway torque rating of 150 in. x lbf.
5. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F.
6. Nonspring-Return Motors: For dampers larger than 25 sq. ft., size motor for running torque rating of 150 in. x lbf and breakaway torque rating of 300 in. x lbf.
7. Electrical Connection: 115 V, single phase, 60 Hz.

K. Accessories:

1. Auxiliary switches for signaling.
2. Test and reset switches, remote mounted.
2.8 FLANGE CONNECTORS

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

1. CL Ward & Family Inc.
2. Ductmate Industries, Inc.
3. Hardcast, Inc.
4. Nexus PDQ.
5. Ward Industries.

B. Description: factory-fabricated, slide-on transverse flange connectors, gaskets, and components.

C. Material: Galvanized steel.

D. Gage and Shape: Match connecting ductwork.

2.9 TURNING VANES

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

1. Aero-Dyne Sound Control Company.
2. CL WARD & Family Inc.
3. Ductmate Industries, Inc.
4. Duro Dyne Inc.
5. Elgen Manufacturing.
6. Hardcast, Inc.
7. METALAIRE, Inc.
8. SEMCO LLC.

B. Manufactured Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.


C. Manufactured Turning Vanes for Nonmetal Ducts: Fabricate curved blades of resin-bonded fiberglass with acrylic polymer coating; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

D. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 4-3, "Vanes and Vane Runners," and 4-4, "Vane Support in Elbows."

E. Vane Construction: Double wall.

2.10 DUCT-MOUNTED ACCESS DOORS

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

1. Aire Technologies.
2. American Warming and Ventilating.
3. Cesco Products.
4. CL WARD & Family Inc.
5. Ductmate Industries, Inc.
7. Flexmaster U.S.A., Inc.
9. McGill AirFlow LLC.
10. Nailor Industries Inc.
11. Pottorff.
12. Ventfabrics, Inc.


1. Door:
   a. Double wall, rectangular.
   b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
   c. Vision panel.
   d. Hinges and Latches: 1-by-1-inch butt or piano hinge and cam latches.
   e. Fabricate doors airtight and suitable for duct pressure class.

2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
3. Number of Hinges and Locks:
   a. Access Doors Less Than 12 Inches Square: No hinges and two sash locks.
   b. Access Doors up to 18 Inches Square: Continuous and two sash locks.
   c. Access Doors up to 24 by 48 Inches: Continuous and two compression latches with outside and inside handles.
   d. Access Doors Larger Than 24 by 48 Inches: Continuous and two compression latches with outside and inside handles.

C. Pressure Relief Access Door:

1. Door and Frame Material: Galvanized sheet steel.
2. Door: Double wall with insulation fill with metal thickness applicable for duct pressure class.
3. Operation: Open outward for positive-pressure ducts and inward for negative-pressure ducts.
4. Factory set at 3.0- to 8.0-inch wg.
5. Doors close when pressures are within set-point range.
6. Hinge: Continuous piano.
7. Latches: Cam.
8. Seal: Neoprene or foam rubber.

2.11 DUCT ACCESS PANEL ASSEMBLIES

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

1. 3M.
2. Ductmate Industries, Inc.
3. Flame Gard, Inc.
B. Labeled according to UL 1978 by an NRTL.

C. Panel and Frame: Minimum thickness 0.0528-inch carbon steel.

D. Fasteners: Stainless steel. Panel fasteners shall not penetrate duct wall.

E. Gasket: Comply with NFPA 96; grease-tight, high-temperature ceramic fiber, rated for minimum 2000 deg F.

F. Minimum Pressure Rating: 10-inch wg, positive or negative.

2.12 FLEXIBLE CONNECTORS

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

1. CL WARD & Family Inc.
2. Ductmate Industries, Inc.
3. Duro Dyne Inc.
4. Elgen Manufacturing.
5. Hardcast, Inc.
6. JP Lamborn Co.
7. Venfabrics, Inc.
8. Ward Industries.

B. Materials: Flame-retardant or noncombustible fabrics.

C. Coatings and Adhesives: Comply with UL 181, Class 1.

D. Metal-Edged Connectors: Factory fabricated with a fabric strip 3-1/2 inches wide attached to two strips of 2-3/4-inch- wide, 0.028-inch- thick, galvanized sheet steel or 0.032-inch- thick aluminum sheets. Provide metal compatible with connected ducts.

   1. Minimum Weight: 26 oz./sq. yd..
   2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
   3. Service Temperature: Minus 40 to plus 200 deg F.

   1. Minimum Weight: 24 oz./sq. yd..
   2. Tensile Strength: 530 lbf/inch in the warp and 440 lbf/inch in the filling.
   3. Service Temperature: Minus 50 to plus 250 deg F.

2.13 FLEXIBLE DUCTS

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

1. Flexmaster U.S.A., Inc.
2. Flex-Tek Group.
3. JP Lamborn Co.
4. McGill AirFlow LLC.
5. Ward Industries.

B. Noninsulated, Flexible Duct: UL 181, Class 1, 2-ply vinyl film supported by helically wound, spring-steel wire.
   1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.
   3. Temperature Range: Minus 10 to plus 160 deg F.

C. Insulated, Flexible Duct: UL 181, Class 1, aluminum laminate and polyester film with latex adhesive supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene vapor-barrier film.
   1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.
   3. Temperature Range: Minus 20 to plus 210 deg F.
   4. Insulation R-value: Comply with ASHRAE/IESNA 90.1.

D. Flexible Duct Connectors:
   1. 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.

2.14 DUCT ACCESSORY HARDWARE

2.14.1 Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.

2.14.2 Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

PART 3 - EXECUTION

3.1 INSTALLATION

3.1.1 Duct Accessories: Install duct accessories according to applicable details in SMACNA’s "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.

3.1.2 Accessories: Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.

3.1.3 Backdraft Dampers: Install backdraft OR control dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.

3.1.4 Volume Dampers: Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.
1. Install steel volume dampers in steel ducts.
2. Install aluminum volume dampers in aluminum ducts.

E. Set dampers to fully open position before testing, adjusting, and balancing.

F. Install test holes at fan inlets and outlets and elsewhere as indicated.

G. Install fire and smoke dampers according to UL listing.

H. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:
   1. On both sides of duct coils.
   2. Upstream and downstream from duct filters.
   3. At outdoor-air intakes and mixed-air plenums.
   4. At drain pans and seals.
   5. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.
   6. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
   7. At each change in direction and at maximum 50-foot spacing.
   8. Upstream from turning vanes.
   9. Upstream or downstream from duct silencers.
   10. Control devices requiring inspection.
   11. At louvers.
   12. Elsewhere as indicated.

I. Install access doors with swing against duct static pressure.

J. Access Door Sizes:
   1. One-Hand or Inspection Access: 8 by 5 inches.
   2. Two-Hand Access: 12 by 6 inches.

K. Label access doors according to Section 23 05 53 "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.

L. Install flexible connectors to connect ducts to equipment.

M. Connect terminal units to supply ducts directly or with maximum 12-inch lengths of flexible duct. Do not use flexible ducts to change directions. No flex duct on VAV boxes.

N. Connect diffusers or light troffer boots to ducts directly or with maximum 60-inch lengths of flexible duct clamped or strapped in place. No flex duct allowed where installation is exposed.

O. Connect flexible ducts to metal ducts with draw bands.

P. Install duct test holes where required for testing and balancing purposes.
3.2 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Operate dampers to verify full range of movement.
2. Inspect locations of access doors and verify that purpose of access door can be performed.
3. Operate fire and smoke dampers to verify full range of movement and verify that proper heat-response device is installed.
4. Inspect turning vanes for proper and secure installation.

END OF SECTION 23 33 00
SECTION 23 34 16 - CENTRIFUGAL HVAC FANS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: For each product.
   1. Backward-inclined centrifugal fans.
   2. Forward-curved centrifugal fans.

1.2 ACTION SUBMITTALS

A. Product Data:
   1. Include rated capacities, furnished specialties, and accessories for each fan.
   2. Certified fan performance curves with system operating conditions indicated.
   3. Certified fan sound-power ratings.
   4. Motor ratings and electrical characteristics, plus motor and electrical accessories.
   5. Material thickness and finishes, including color charts.
   6. Dampers, including housings, linkages, and operators.

B. Shop Drawings:
   1. Include plans, elevations, sections, and attachment details.
   2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   3. Include diagrams for power, signal, and control wiring.
   4. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
   5. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base weights.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show fan room layout and relationships between components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate and certify field measurements.

B. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For centrifugal fans to include in emergency, operation, and maintenance manuals.
1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Belts: One set(s) for each belt-driven unit.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. AMCA Compliance: Comply with AMCA performance requirements and bear the AMCA-Certified Ratings Seal.

B. Capacities and Characteristics:
   1. See schedule on drawing.

2.2 BACKWARD-INCLINED CENTRIFUGAL FANS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Acme Engineering & Manufacturing Corp.
   2. Aerovent.
   3. Central Blower Company.
   5. Cincinnati Fan.
   6. CML Northern Blower Inc.
   7. Howden Buffalo Inc.
   8. Loren Cook Company.

B. Description:
   1. Factory-fabricated, -assembled, -tested, and -finished, belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor, drive assembly, and support structure.
   2. Deliver fans as factory-assembled units, to the extent allowable by shipping limitations.
   3. Factory-installed and -wired disconnect switch.

C. Housings:
   1. Formed panels to make curved-scroll housings with shaped cutoff.
   2. Panel Bracing: Steel angle- or channel-iron member supports for mounting and supporting fan scroll, wheel, motor, and accessories.
   3. Horizontally split, bolted-flange housing.
   4. Spun inlet cone with flange.
   5. Outlet flange.

D. Backward-Inclined Wheels:
   1. Single-width-single-inlet and double-width-double-inlet construction with curved inlet flange, backplate, backward-inclined blades, and fastened to shaft with set screws.
   2. Welded or riveted to flange and backplate; cast-iron or cast-steel hub riveted to backplate.
E. Shafts:
1. Statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with adjustable alignment and belt tensioning.
2. Turned, ground, and polished hot-rolled steel with keyway. Ship with protective coating of lubricating oil.
3. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.

F. Grease-Lubricated Shaft Bearings:
1. Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing.

G. Belt Drives:
1. Factory mounted, with adjustable alignment and belt tensioning.
2. Service Factor Based on Fan Motor Size: 1.5.
3. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
4. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
5. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
6. Belt Guards: Fabricate to comply with OSHA and SMACNA requirements of diamond-mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short circuiting vibration isolation. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.

H. Accessories:
2. Scroll Drain Connection: NPS 1 steel pipe coupling welded to low point of fan scroll.
3. Companion Flanges: Rolled flanges for duct connections of same material as housing.
4. Variable Inlet Vanes: With blades supported at both ends with two permanently lubricated bearings of same material as housing. Variable mechanism terminating in single control lever with control shaft for double-width fans.
5. Discharge Dampers: Assembly with opposed blades constructed of two plates formed around and to shaft, channel frame, and sealed ball bearings; with blades linked outside of airstream to single control lever of same material as housing.
6. Inlet Screens: Grid screen of same material as housing.
7. Shaft Cooler: Metal disk between bearings and fan wheel, designed to dissipate heat from shaft.

2.3 FORWARD-CURVED CENTRIFUGAL FANS
A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Acme Engineering & Manufacturing, Inc.
2. Central Blower Company.
3. Howden Buffalo Inc.
4. Lau Industries.
B. Description:
1. Factory-fabricated, -assembled, -tested, and -finished, belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor, drive assembly, and support structure.
2. Deliver fans as factory-assembled units, to the extent allowable by shipping limitations.
3. Factory-installed and -wired disconnect switch.

C. Housings:
1. Formed panels to make curved-scroll housings with shaped cutoff.
2. Panel Bracing: Steel angle- or channel-iron member supports for mounting and supporting fan scroll, wheel, motor, and accessories.
3. Horizontally split, bolted-flange housing.
4. Spun inlet cone with flange.
5. Outlet flange.

D. Forward-Curved Wheels:
1. Black-enameled or galvanized-steel construction with inlet flange, backplate, shallow blades with inlet and tip curved forward in direction of airflow.
2. Mechanically secured to flange and backplate; cast-steel hub swaged to backplate and fastened to shaft with set screws.

E. Shafts:
1. Statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with adjustable alignment and belt tensioning.
2. Turned, ground, and polished hot-rolled steel with keyway. Ship with protective coating of lubricating oil.
3. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.

F. Grease-Lubricated Shaft Bearings:
1. Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing.

G. Belt Drives:
1. Factory mounted, with adjustable alignment and belt tensioning.
2. Service Factor Based on Fan Motor Size: 1.5.
3. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
4. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
5. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
6. Belt Guards: Fabricate to comply with OSHA and SMACNA requirements of diamond-mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short circuiting vibration isolation. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.

H. Accessories:
2. Scroll Drain Connection: NPS 1 steel pipe coupling welded to low point of fan scroll.
3. Companion Flanges: Rolled flanges for duct connections of same material as housing.
4. Variable Inlet Vanes: With blades supported at both ends with two permanently lubricated bearings of same material as housing. Variable mechanism terminating in single control lever with control shaft for double-width fans.
5. Discharge Dampers: Assembly with opposed blades constructed of two plates formed around and to shaft, channel frame, and sealed ball bearings; with blades linked outside of airstream to single control lever of same material as housing.
6. Inlet Screens: Grid screen of same material as housing.
7. Shaft Cooler: Metal disk between bearings and fan wheel, designed to dissipate heat from shaft.

2.4 SOURCE QUALITY CONTROL

A. Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install centrifugal fans level and plumb.

B. Disassemble and reassemble units, as required for moving to the final location, according to manufacturer's written instructions.

C. Lift and support units with manufacturer's designated lifting or supporting points.

D. Equipment Mounting:

1. Comply with requirements for vibration isolation and seismic control devices specified in Section 23 05 48 "Vibration and Seismic Controls for HVAC."

E. Curb Support: Install roof curb on roof structure, level and secure, according to "The NRCA Roofing and Waterproofing Manual," Low-Slope Membrane Roofing Construction Details Section, Illustration "Raised Curb Detail for Rooftop Air Handling Units and Ducts." Install and secure centrifugal fans on curbs, and coordinate roof penetrations and flashing with roof construction. Comply with requirements for vibration isolation and seismic control devices specified in Section 23 05 48 "Vibration and Seismic Controls for HVAC."

F. Install units with clearances for service and maintenance.

G. Label fans according to requirements specified in Section 23 05 53 "Identification for HVAC Piping and Equipment."
3.2 CONNECTIONS

A. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Section 23 33 00 "Air Duct Accessories."

B. Install ducts adjacent to fans to allow service and maintenance.

C. Install piping from scroll drain connection, with trap with seal equal to 1.5 times specified static pressure, to nearest floor drain with pipe sizes matching the drain connection.

3.3 FIELD QUALITY CONTROL

A. Perform the following tests and inspections[with the assistance of a factory-authorized service representative]:

1. Verify that shipping, blocking, and bracing are removed.
2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
3. Verify that cleaning and adjusting are complete.
4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
5. Adjust belt tension.
6. Adjust damper linkages for proper damper operation.
7. Verify lubrication for bearings and other moving parts.
8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
9. See Section 23 05 93 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing procedures.
10. Remove and replace malfunctioning units and retest as specified above.

B. Test and adjust controls and safeties. Controls and equipment will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

END OF SECTION 23 34 16
SECTION 23 34 23 - HVAC POWER VENTILATORS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Centrifugal roof ventilators.

1.2 ACTION SUBMITTALS

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

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

   1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   2. Wiring Diagrams: For power, signal, and control wiring.
   3. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
   4. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.

1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.4 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. AMCA Compliance: Fans shall have AMCA-Certified performance ratings and shall bear the AMCA-Certified Ratings Seal.

PART 2 - PRODUCTS

2.1 CENTRIFUGAL ROOF VENTILATORS

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

   1. Aerovent
   2. Greenheck Fan Corporation.
   3. Loren Cook Company.
4. PennBarry.

B. Housing: Removable, spun-aluminum, dome top and outlet baffle.
   1. Upblast Units: Provide spun-aluminum discharge baffle to direct discharge air upward, with rain and snow drains.
   2. Hinged Subbase: Galvanized-steel hinged arrangement permitting service and maintenance.

C. Fan Wheels: Aluminum hub and wheel with backward-inclined blades.

D. Belt Drives:
   1. Resiliently mounted to housing.
   2. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
   5. Fan and motor isolated from exhaust airstream.

E. Accessories:
   1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
   2. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.
   3. Bird Screens: Removable, 1/2-inch mesh, aluminum or brass wire.
   4. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.
   5. Motorized Dampers: Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.

F. Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch- thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch wood nailer. Size as required to suit roof opening and fan base.
   2. Overall Height: 12 inches.
   3. Sound Curb: Curb with sound-absorbing insulation.
   5. Metal Liner: Galvanized steel.
   6. Mounting Pedestal: Galvanized steel with removable access panel.

G. Capacities and Characteristics:
   1. See Schedule on Drawings.

2.2 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 23 05 13 "Common Motor Requirements for HVAC Equipment."
   1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

B. Enclosure Type: Totally enclosed, fan cooled.
2.3 SOURCE QUALITY CONTROL

A. Certify sound-power level ratings according to AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.

B. Certify fan performance ratings, including flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests according to AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating." Label fans with the AMCA-Certified Ratings Seal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Equipment Mounting:
   1. Comply with requirements for vibration isolation and seismic control devices specified in Section 23 05 48 "Vibration and Seismic Controls for HVAC."
   2. Comply with requirements for vibration isolation devices specified in Section 23 05 48.13 "Vibration Controls for HVAC."

B. Secure roof-mounted fans to roof curbs with cadmium-plated hardware. See Section 07 72 00 "Roof Accessories" for installation of roof curbs.

C. Install units with clearances for service and maintenance.

D. Label units according to requirements specified in Section 23 05 53 "Identification for HVAC Piping and Equipment."

3.2 CONNECTIONS

A. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Section 23 33 00 "Air Duct Accessories."

B. Install ducts adjacent to power ventilators to allow service and maintenance.

C. Ground equipment according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."

D. Connect wiring according to Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections.
   1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:
1. Verify that shipping, blocking, and bracing are removed.
2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
3. Verify that cleaning and adjusting are complete.
4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
5. Adjust belt tension.
6. Adjust damper linkages for proper damper operation.
7. Verify lubrication for bearings and other moving parts.
8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
9. Disable automatic temperature-control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.
10. Shut unit down and reconnect automatic temperature-control operators.
11. Remove and replace malfunctioning units and retest as specified above.

C. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Prepare test and inspection reports.

3.4 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Comply with requirements in Section 23 05 93 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing procedures.

D. Replace fan and motor pulleys as required to achieve design airflow.

E. Lubricate bearings.

END OF SECTION 23 34 23
SECTION 23 36 00 - AIR TERMINAL UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Shutoff, single-duct air terminal units.

1.2 ACTION SUBMITTALS

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

B. LEED Submittals:
   1. Product Data for Prerequisite EQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."

C. Shop Drawings: For air terminal units. Include plans, elevations, sections, details, and attachments to other work.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-Up."

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Structural Performance: Hangers and supports and seismic restraints shall withstand the effects of gravity and seismic loads and stresses within limits and under conditions described in SMACNA's
2.2 SHUTOFF, SINGLE-DUCT AIR TERMINAL UNITS

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

1. Anemostat Products.
2. Carnes Company.
4. METALAIRE, Inc.
5. Trane
6. Titus

B. Configuration: Volume-damper assembly inside unit casing with control components inside a protective metal shroud.

C. Casing: 0.034-inch steel, single wall.

1. Casing Lining: Adhesive attached, 1-inch-thick, coated, fibrous-glass duct liner complying with ASTM C 1071, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.

   a. Cover liner with nonporous foil.

2. Casing Lining: Adhesive attached, 1-inch-thick, polyurethane foam insulation complying with UL 181 erosion requirements, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.

3. Air Inlet: Round stub connection or S-slip and drive connections for duct attachment.
5. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket.
6. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

D. Regulator Assembly: System-air-powered bellows section incorporating polypropylene bellows for volume regulation and thermostatic control. Bellows shall operate at temperatures from 0 to 140 deg F, shall be impervious to moisture and fungus, shall be suitable for 10-inch wg static pressure, and shall be factory tested for leaks.

E. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.

1. Maximum Damper Leakage: ARI 880 rated, 3 percent of nominal airflow at 3-inch wg inlet static pressure.

F. Electric Controls: Damper actuator and thermostat.

G. Direct Digital Controls: Single-package unitary controller and actuator specified in Section 23 09 23 "Direct Digital Control (DDC) System for HVAC."
2.3 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.

B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

C. Steel Cables: Stainless steel complying with ASTM A 492.

D. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

E. Air Terminal Unit Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

F. Trapeze and Riser Supports: Steel shapes and plates for units with steel casings; aluminum for units with aluminum casings.

2.4 SEISMIC-RESTRAINT DEVICES

A. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an agency acceptable to authorities having jurisdiction.

1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.

B. Channel Support System: Shop- or field-fabricated support assembly made of slotted steel channels rated in tension, compression, and torsion forces and with accessories for attachment to braced component at one end and to building structure at the other end. Include matching components and corrosion-resistant coating.

C. Restraint Cables: ASTM A 492, stainless-steel cables with end connections made of cadmium-plated steel assemblies with brackets, swivel, and bolts designed for restraining cable service; with an automatic-locking and clamping device or double-cable clips.

D. Hanger Rod Stiffener: Reinforcing steel angle clamped to hanger rod.

E. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

2.5 SOURCE QUALITY CONTROL

A. Factory Tests: Test assembled air terminal units according to ARI 880.

1. Label each air terminal unit with plan number, nominal airflow, maximum and minimum factory-set airflows, and ARI certification seal.
PART 3 - EXECUTION

3.1 INSTALLATION
A. Install air terminal units according to NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems."
B. Install air terminal units level and plumb. Maintain sufficient clearance for normal service and maintenance.
C. Install wall-mounted thermostats.

3.2 HANGER AND SUPPORT INSTALLATION
A. Comply with SMACNA’s "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."
B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
   1. Where practical, install concrete inserts before placing concrete.
   2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
   3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes and for slabs more than 4 inches thick.
   4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes and for slabs less than 4 inches thick.
   5. Do not use powder-actuated concrete fasteners for seismic restraints.
C. Hangers Exposed to View: Threaded rod and angle or channel supports.
D. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.3 SEISMIC-RESTRAINT-DEVICE INSTALLATION
A. Install hangers and braces designed to support the air terminal units and to restrain against seismic forces required by applicable building codes. Comply with SMACNA’s "Seismic Restraint Manual: Guidelines for Mechanical Systems."
B. Select seismic-restraint devices with capacities adequate to carry present and future static and seismic loads.
C. Install cables so they do not bend across edges of adjacent equipment or building structure.
D. Install cable restraints on air terminal units that are suspended with vibration isolators.
E. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction.
F. Attachment to Structure: If specific attachment is not indicated, anchor bracing and restraints to structure, to flanges of beams, to upper truss chords of bar joists, or to concrete members.
G. Drilling for and Setting Anchors:

1. Identify position of reinforcing steel and other embedded items before drilling holes for anchors. Do not damage existing reinforcement or embedded items during drilling. Notify the Architect if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.

2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.

3. Wedge Anchors: Protect threads from damage during anchor installation. Install heavy-duty sleeve anchors with sleeve fully engaged in the structural element to which anchor is to be fastened.

4. Set anchors to manufacturer's recommended torque, using a torque wrench.

5. Install zinc-coated steel anchors for interior applications and stainless-steel anchors for applications exposed to weather.

3.4 CONNECTIONS

A. Install piping adjacent to air terminal unit to allow service and maintenance.

B. Hot-Water Piping: In addition to requirements in Section 23 21 13 "Hydronic Piping" and Section 23 21 16 "Hydronic Piping Specialties," Section 15179 "Hydronic Piping Specialties," connect heating coils to supply with shutoff valve, strainer, control valve, and union or flange; and to return with balancing valve and union or flange.

C. Connect ducts to air terminal units according to Section 23 31 13 "Metal Ducts." Section 23 31 16 "Nonmetal Ducts."

D. Make connections to air terminal units with flexible connectors complying with requirements in Section 23 33 00 "Air Duct Accessories."

3.5 IDENTIFICATION

A. Label each air terminal unit with plan number, nominal airflow, and maximum and minimum factory-set airflows. Comply with requirements in Section 23 05 53 "Identification for HVAC Piping and Equipment" for equipment labels and warning signs and labels.

3.6 FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:

1. After installing air terminal units and after electrical circuitry has been energized, test for compliance with requirements.

2. Leak Test: After installation, fill water coils and test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Air terminal unit will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.7 STARTUP SERVICE

A. Perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Verify that inlet duct connections are as recommended by air terminal unit manufacturer to achieve proper performance.
3. Verify that controls and control enclosure are accessible.
4. Verify that control connections are complete.
5. Verify that nameplate and identification tag are visible.
6. Verify that controls respond to inputs as specified.

3.8 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain air terminal units.

END OF SECTION 23 36 00
SECTION 23 37 13 - DIFFUSERS, REGISTERS, AND GRILLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Round ceiling diffusers.
   2. Rectangular and square ceiling diffusers.
   3. Perforated diffusers.
   4. Louver face diffusers.
   5. Linear bar diffusers.
   6. Linear slot diffusers.
   7. Adjustable bar registers and grilles.
   8. Fixed face registers and grilles.
   9. Linear bar grilles.

B. Related Sections:
   1. Section 08 91 16 "Operable Wall Louvers" and Section 08 91 19 "Fixed 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.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated, include the following:
   1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
   2. Diffuser, Register, and Grille Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

B. Samples: For each exposed product and for each color and texture specified.

PART 2 - PRODUCTS

2.1 CEILING DIFFUSERS

A. Ceiling Diffusers as scheduled on the drawings:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Carnes Company.
      b. Krueger
      c. METALAIRE, Inc.
Diffusers, Registers, and Grilles 23 37 13 - 2

d. Nailor Industries Inc.
e. Price Industries.
f. Titus.

2. Devices shall be specifically designed for variable-air-volume flows.

2.2 Ceiling Linear Slot Outlets

A. Linear Diffuser as scheduled on drawings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Carnes Company.
   b. Krueger
   c. METALAIRE, Inc.
   d. Nailor Industries Inc.
   e. Price Industries.
   f. Titus.

2. Devices shall be specifically designed for variable-air-volume flows.
3. Material: As scheduled.

2.3 Registers and Grilles

A. Registers and Grilles as scheduled on drawings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Carnes Company.
   b. Krueger
   c. METALAIRE, Inc.
   d. Nailor Industries Inc.
   e. Price Industries.
   f. Titus.

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 INSTALLATION
   A. Install diffusers, registers, and grilles level and plumb.
   B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.
   C. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.2 ADJUSTING
   A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION 23 37 13
SECTION 23 37 23 - HVAC GRAVITY VENTILATORS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Roof hoods.

1.2 PERFORMANCE REQUIREMENTS

A. Structural Performance: Ventilators shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated without permanent deformation of ventilator components, noise or metal fatigue caused by ventilator blade rattle or flutter, or permanent damage to fasteners and anchors. Wind pressures shall be considered to act normal to the face of the building.
   1. Wind Loads: Determine loads based on pressures as indicated on Drawings.

B. Seismic Performance: Ventilators, including attachments to other construction, shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
   1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

1.3 ACTION SUBMITTALS

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

B. LEED Submittals:
   1. Product Data for Prerequisite IEQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."

C. Shop Drawings: For gravity ventilators. Include plans, elevations, sections, details, ventilator attachments to curbs, and curb attachments to roof structure.

D. Samples: For each exposed product and for each color and texture specified.

E. Delegated-Design Submittal: For shop-fabricated ventilators indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
   1. Detail fabrication and assembly of shop-fabricated ventilators.

1.4 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For ventilators, accessories, and components, from manufacturer.
1.5 COORDINATION

A. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Aluminum Extrusions: ASTM B 221, Alloy 6063-T5 or T-52.

B. Aluminum Sheet: ASTM B 209, Alloy 3003 or 5005 with temper as required for forming or as otherwise recommended by metal producer for required finish.

C. Galvanized-Steel Sheet: ASTM A 653/A 653M, G90 zinc coating, mill phosphatized.

D. Fasteners: Same basic metal and alloy as fastened metal or 300 Series stainless steel unless otherwise indicated. Do not use metals that are incompatible with joined materials.

1. Use types and sizes to suit unit installation conditions.
2. Use hex-head or Phillips pan-head screws for exposed fasteners unless otherwise indicated.

E. Post-Installed Fasteners for Concrete and Masonry: Torque-controlled expansion anchors made from stainless-steel components, with capability to sustain without failure a load equal to 4 times the loads imposed for concrete, or 6 times the load imposed for masonry, as determined by testing per ASTM E 488, conducted by a qualified independent testing agency.

F. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D 1187.

2.2 FABRICATION, GENERAL

A. Factory fabricate gravity ventilators to minimize field splicing and assembly. Disassemble units to the minimum extent as necessary for shipping and handling. Clearly mark units for reassembly and coordinated installation.

B. Fabricate frames, including integral bases, to fit in openings of sizes indicated, with allowances made for fabrication and installation tolerances, adjoining material tolerances, and perimeter sealant joints.

C. Fabricate units with closely fitted joints and exposed connections accurately located and secured.

D. Fabricate supports, anchorages, and accessories required for complete assembly.

2.3 ROOF HOODS

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

1. Acme Engineering & Manufacturing Corporation.
2. Aerovent.
3. Carnes Company.
4. Loren Cook Company.
5. PennBarry.
6. Twin City Fan & Blower.

B. Factory fabricated according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figures 6-6 and 6-7.

C. Materials: Aluminum sheet, minimum 0.063-inch-thick base and 0.050-inch-thick hood; suitably reinforced.

D. Roof Curbs: Galvanized-steel sheet; with mitered and welded corners; 1-1/2-inch-thick, rigid fiberglass insulation adhered to inside walls; and 1-1/2-inch wood nailer. Size as required to fit roof opening and ventilator base.
   2. Overall Height: 18 inches.

E. Bird Screening: Stainless-steel, 1/2-inch-square mesh, 0.047-inch wire.

F. Gravity Ventilator Finish:
   1. Surface Preparation: Clean surfaces of dirt, grease, and other contaminants. Clean welds, mechanical connections, and abraded areas and repair galvanizing according to ASTM A 780. Apply a conversion coating suited to the organic coating to be applied over it.
   2. Baked-Enamel Finish: Immediately after cleaning and pretreating, apply manufacturer's standard finish consisting of prime coat and thermosetting topcoat, with a minimum dry film thickness of 1 mil for topcoat and an overall minimum dry film thickness of 2 mils.
      a. Color and Gloss: As selected by Architect from manufacturer's full range.

G. Capacities and Characteristics:
   1. As Scheduled on Drawings.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install gravity ventilators level, plumb, and at indicated alignment with adjacent work.

B. Secure gravity ventilators to roof curbs with cadmium-plated hardware. Use concealed anchorages where possible. Refer to Section 07 72 00 "Roof Accessories."

C. Install gravity ventilators with clearances for service and maintenance.

D. Install perimeter reveals and openings of uniform width for sealants and joint fillers, as indicated.

E. Install concealed gaskets, flashings, joint fillers, and insulation as installation progresses. Comply with Section 07 92 00 "Joint Sealants" for sealants applied during installation.

F. Label gravity ventilators according to requirements specified in Section 23 05 53 "Identification for HVAC Piping and Equipment."
G. Protect galvanized and nonferrous-metal surfaces from corrosion or galvanic action by applying a heavy coating of bituminous paint on surfaces that will be in contact with concrete, masonry, or dissimilar metals.

H. Repair finishes damaged by cutting, welding, soldering, and grinding. Restore finishes so no evidence remains of corrective work. Return items that cannot be refinished in the field to the factory, make required alterations, and refinish entire unit or provide new units.

END OF SECTION 23 37 23
SECTION 23 72 00 - AIR-TO-AIR ENERGY RECOVERY EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Heat wheels.
2. Packaged energy recovery units.

1.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Air-to-air energy recovery equipment shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. LEED Submittals:

1. Product Data for Credit EA 4: Documentation indicating that equipment and refrigerants comply.
2. Product Data for Prerequisite IEQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."

C. Shop Drawings: For air-to-air energy recovery equipment. Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Wiring Diagrams: For power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For air-to-air energy recovery equipment, accessories, and components, from manufacturer.
1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air-to-air energy recovery equipment to include in maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents. Provide these items after substantial completion.

1. Filters: One set(s) of each type of filter specified.
2. Fan Belts: One set(s) of belts for each belt-driven fan in energy recovery units.
3. Wheel Belts: One set(s) of belts for each heat wheel.

1.8 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ARI Compliance:


C. ASHRAE Compliance:

1. Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
2. Capacity ratings for air-to-air energy recovery equipment shall comply with ASHRAE 84, "Method of Testing Air-to-Air Heat Exchangers."

D. NRCA Compliance: Roof curbs for roof-mounted equipment shall be constructed according to recommendations of NRCA.

1.9 COORDINATION

A. Coordinate layout and installation of air-to-air energy recovery equipment 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 sizes and locations of concrete bases with actual equipment provided.

C. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

1.10 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of air-to-air energy recovery equipment that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Packaged Energy Recovery Units: Five years.

PART 2 - PRODUCTS

2.1 HEAT WHEELS

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

1. Aaon.

B. Casing:

1. Steel with standard factory-painted finish.
2. Integral purge section limiting carryover of exhaust air to between 0.05 percent at 1.6-inch wg and 0.20 percent at 4-inch wg differential pressure.
3. Casing seals on periphery of rotor and on duct divider and purge section.
4. Support vertical rotors on grease-lubricated ball bearings having extended grease fittings or permanently lubricated bearings. Support horizontal rotors on tapered roller bearing.

C. Rotor: Aluminum segmented wheel strengthened with radial spokes, with nontoxic, noncorrosive, silica-gel desiccant coating.

1. Maximum Solid Size for Media to Pass: 500 micrometer.

D. Rotor: Glass-fiber segmented wheel strengthened with radial spokes impregnated with nonmigrating, water-selective, molecular-sieve desiccant coating.

1. Maximum Solid Size for Media to Pass: 800 micrometer.

E. Drive: Fractional horsepower motor and gear reducer, with speed changed by variable frequency controller and self-adjusting multilink belt around outside of rotor.

1. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 23 05 13 "Common Motor Requirements for HVAC Equipment."
2. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

F. Controls:
1. Variable frequency controller, factory mounted and wired.

2.2 PACKAGED ENERGY RECOVERY UNITS

A. Manufacturers: Subject to compliance with requirements, provide products by the following:
   1. Aaon.

B. Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

C. Housing: Manufacturer's standard construction with corrosion-protection coating and exterior finish, gasketed and caulked weathertight, hinged access doors with neoprene gaskets for inspection and access to internal parts, minimum 1-inch-thick thermal insulation, knockouts for electrical and piping connections, exterior drain connection, and lifting lugs.
   1. Inlet: with damper for exhaust and supply.
   2. Roof Curb: Refer to Section 07 72 00 "Roof Accessories" for roof curbs and equipment supports.


E. Supply and Exhaust Fans: Backward-inclined, plenum centrifugal fan with restrained, spring isolators flexible duct connections.
   1. Motor and Drive: Direct driven.
   2. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 23 05 13 "Common Motor Requirements for HVAC Equipment."
   3. 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.
   4. Spring isolators on each fan having 1-inch static deflection.

F. Final Filter: Extended-Surface, Nonsupported-Media Filters:
   1. Comply with NFPA 90A.
   2. Filter Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lift out from access plenum.
   4. MERV: 13, according to ASHRAE 52.2.
   5. Media: Fibrous material constructed so individual pleats are maintained in tapered form by flexible internal supports under rated-airflow conditions.
   7. Mounting Frames: Welded, galvanized steel with gaskets and fasteners, suitable for bolting together into built-up filter banks with space for MERV 8 prefilter.

G. Cooling Coils: Rated according to ARI 410 and ASHRAE 33, and bearing the ARI label.
1. Access: Fabricate coil section to allow removal and replacement of coil and to allow in-place access for service and maintenance of coil(s).
2. Casing: Manufacturer's standard material.
3. Tubes: Copper.
4. Tube Headers: Copper.
5. Fins: Aluminum.
6. Fin and Tube Joint: Mechanical bond.
7. Leak Test: Coils shall be leak tested with air under water.
8. Refrigerant Coils:
   a. Capacity Reduction: Circuit coils for interleaved control.
   b. Suction and Distributor: Seamless copper tube with brazed joints.

H. Cooling-Coil Condensate Drain Pans:
1. Fabricated from stainless-steel sheet and sloped in multiple planes to collect and drain condensate from cooling coils, coil piping connections, coil headers, and return bends.
2. Complying with requirements in ASHRAE 62.1.
3. Drain Connections: At low point of pan with threaded nipple.
4. Units with stacked coils shall have an intermediate drain pan to collect and drain condensate from top coil.

I. Hot-Water Coils: Rated according to ARI 410 and ASHRAE 33, and bearing the ARI label.
1. Access: Fabricate coil section to allow removal and replacement of coil and to allow in-place access for service and maintenance of coil(s).
2. Casing: Manufacturer's standard material.
3. Tubes: Copper.
4. Tube Headers: Copper.
5. Fins: Aluminum.
6. Fin and Tube Joint: Mechanical bond.
7. Leak Test: Coils shall be leak tested with air under water.

J. Heat Pump Heating and Cooling
1. Provide factory geothermal heat pump to provide cooling.

K. Piping and Wiring: Fabricate units with space within housing for piping and electrical conduits. Wire motors and controls so only external connections are required during installation.
1. Indoor Enclosure: NEMA 250, Type 12 enclosure contains relays, starters, and terminal strip.
2. Include nonfused disconnect switches.
3. Variable-speed controller to vary fan capacity from 100 to approximately 25 percent.

L. Accessories:
1. Low-Leakage, Isolation Dampers: Double-skin, airfoil-blade, aluminum dampers with compressible jamb seals and extruded-vinyl blade edge seals, in opposed-blade arrangement with cadmium-plated steel operating rods rotating in stainless-steel sleeve sintered bronze or nylon bearings mounted in a single aluminum frame, with operating rods connected with a common linkage, and electric damper operator factory wired. Leakage rate shall not exceed 5 cfm/sq. ft. at 1-inch wg and 9 cfm/sq. ft. at 4-inch wg.
2. Duct flanges.
3. Hinged access doors with quarter-turn latches.

2.3 CONTROLS

A. DDC Controls by project temperature control contractor. See 23 09 23 - DDC System for HVAC.

B. Variable frequency drives for supply and exhaust fans to be factory mounted and wired.

2.4 CAPACITIES AND CHARACTERISTICS

A. See Schedule on Drawings.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine casing insulation materials and filter media before air-to-air energy recovery equipment installation. Reject insulation materials and filter media that are wet, moisture damaged, or mold damaged.

C. Examine roughing-in for electrical services to verify actual locations of connections before installation.

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

3.2 INSTALLATION

A. Install heat wheels so supply and exhaust airstreams flow in opposite directions and rotation is away from exhaust side to purge section to supply side.

1. Install access doors in both supply and exhaust ducts, both upstream and downstream, for access to wheel surfaces, drive motor, and seals.

2. Install removable panels or access doors between supply and exhaust ducts on building side for bypass during startup.

3. Access doors and panels are specified in Section 23 33 00 "Air Duct Accessories."

B. Install floor-mounted units on 4-inch-high concrete base designed to withstand, without damage to equipment, seismic force required by code.

C. Equipment Mounting:

1. Install air-to-air energy recovery equipment on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 03 30 53 "Miscellaneous Cast-in-Place Concrete."

D. Install units with clearances for service and maintenance.
E. Install new filters at completion of equipment installation and before testing, adjusting, and balancing. Provide a new set of filters at substantial completion.

F. Pipe drains from drain pans to nearest floor drain; use ASTM B 88, Type L, drawn-temper copper water tubing with soldered joints, same size as condensate drain connection.

3.3 CONNECTIONS

A. Comply with requirements for piping specified in Section 23 21 13 "Hydronic Piping" and Section 23 21 16 Hydronic Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to unit to allow service and maintenance.

C. Connect piping to units mounted on vibration isolators with flexible connectors.

D. Connect cooling condensate drain pans with air seal trap at connection to drain pan and install cleanouts at changes in pipe direction.

E. Hot Water Piping: Comply with applicable requirements in Section 23 21 13 "Hydronic Piping" and Section 23 21 16 Hydronic Piping Specialties." Install shutoff valve and union or flange at each coil supply connection. Install balancing valve and union or flange at each coil return connection.

F. Refrigerant Piping: Comply with applicable requirements in Section 23 23 00 "Refrigerant Piping."

G. Comply with requirements for ductwork specified in Section 23 31 13 "Metal Ducts."

H. Install electrical devices furnished with units but not factory mounted.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. Perform tests and inspections.
   1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
   2. The temperature control contractor shall be in attendance at all startup activities.

C. Tests and Inspections:
   1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   2. Adjust seals and purge.
   3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
   4. Set initial temperature and humidity set points.
   5. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
D. Air-to-air energy recovery equipment will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.
   1. The temperature control contractor shall be in attendance at all testing and startup activities.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air-to-air energy recovery units.

B. See section 230100 for more requirements.

PART 4 - PROCUREMENT

A. Contract Vemco Inc. for final pricing to be included in bid for this equipment.

PART 5 - SHOP DRAWINGS

A. See proposed shop drawings in this section. Final shop drawing approval by the engineer is pending.

END OF SECTION 23 72 00
### Job Information
- **Job Name:** NAIC DOAS Unit
- **Site Altitude:** 4850 ft
- **Refrigerant:** R-410A

### Static Pressure
- **External:** 3.25 in. w.g.
- **Evaporator:** 0.22 in. w.g.
- **Filters Clean:** 0.21 in. w.g.
- **Dirt Allowance:** 0.75 in. w.g.

### Cooling Section
- **Total Capacity:** 304.33 MBH
- **Sensible Capacity:** 304.33 MBH
- **Latent Capacity:** 0.00 MBH
- **Mixed Air Temp:** 82.50 °F DB, 59.70 °F WB
- **Entering Air Temp:** 82.50 °F DB, 59.70 °F WB
- **Lv Air Temp (Coil):** 68.73 °F DB, 54.99 °F WB
- **Lv Air Temp (Unit):** 70.76 °F DB, 55.71 °F WB

### Water Side Performance:
- **Cooling Flow Rate:** 60 gpm
- **Cooling PD - Heat Exchanger:** 6.83 ft
- **Heating Flow Rate:** 60 gpm
- **Heating PD - Heat Exchanger:** 6.83 ft

### Heating Section
- **Total Capacity:** 302.9 MBH
- **Entering Air Temp:** 41.0 °F DB, 27.9 °F WB
- **Leaving Air Temp:** 54.4 °F DB, 35.9 °F WB
- **Heating CFM:** 25000
- **Fan Temp Rise:** 2.0 °F
- **Heating Type:** Heat Pump

### Electrical Data Circuit 1
- **Rating:** 460/3/60
- **Compressor 1:**
  - **Qty:** 1
  - **HP:** 25000
  - **FLA:** 21.2
- **Compressor 2:**
  - **Qty:** 1
  - **HP:** 25000
  - **FLA:** 24.4

### Electrical Data Circuit 2
- **Rating:** 460/3/60
- **Supply Fan:**
  - **Qty:** 2
  - **HP:** 25.00
  - **FLA:** 31.0
- **Exhaust Fan:**
  - **Qty:** 2
  - **HP:** 25.00
  - **FLA:** 31.0
- **Heatwheel:**
  - **Qty:** 2
  - **HP:** 25.00
  - **FLA:** 31.0
- **Control Circuit:**
  - **Qty:** 1
  - **HP:** 25.00
  - **FLA:** 31.0
### Job Information

- **Job Name:** NAIC DOAS Unit
- **Site Altitude:** 4850 ft
- **Refrigerant:** R-410A

### Static Pressure

- External: 3.25 in. wg.
- Evaporator: 0.22 in. wg.
- Filters Clean: 0.21 in. wg.
- Dirt Allowance: 0.75 in. wg.

### Cooling Section

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<td>Sensible Capacity</td>
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<td>258.06 MBH</td>
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<tr>
<td>Latent Capacity</td>
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</tr>
<tr>
<td>Mixed Air Temp</td>
<td>82.50 °F DB</td>
<td>59.70 °F WB</td>
</tr>
<tr>
<td>Entering Air Temp</td>
<td>82.50 °F DB</td>
<td>59.70 °F WB</td>
</tr>
<tr>
<td>Lv Air Temp (Coil)</td>
<td>68.73 °F DB</td>
<td>54.99 °F WB</td>
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<td>Lv Air Temp (Unit)</td>
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<td>55.71 °F WB</td>
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<tr>
<td>SA Fan RPM / Width</td>
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<tr>
<td>Evaporator Coil</td>
<td>50.6 ft² / 2 Rows / 10 FPI</td>
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<tr>
<td>Evaporator Face Velocity</td>
<td>494.5 fpm</td>
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### Heating Section

- **Heating Type:** Heat Pump
- **Total Capacity:** 302.9 MBH
- **Entering Air Temp:** 41.0 °F DB / 27.9 °F WB
- **Leaving Air Temp:** 54.4 °F DB / 35.9 °F WB
- **Heating CFM:** 25000
- **Fan Temp Rise:** 2.0 °F
- **PreHeat Type:** Hot Water Preheat (Emergency Heat)
- **Heating CFM:** 25000
- **Total Capacity:** 1,590 MBH
- **Entering Air Temp:** -25 DB / -25 °F WB
- **Preheat Leaving Air Temp:** 34.0 °F DB / 23.6°F WB
- **Entering Water:** 180.0 °F
- **Leaving Water:** 158.9 °F
- **GPM / Head:** 160 / 3.95 ft
- **Air PD:** 0.17 in wg.
- **FA / RD / FPI / FV:** 37.50 ft² / 2 / 06 / 654.0

### Water Side Performance:

- **Cooling Flow Rate:** 60 gpm
- **Cooling PD - Heat Exchanger:** 6.83 ft
- **Cooling PD - Total:** 9.04 ft
- **Cooling Ent. / Lv. Water Temp:** 90 / 103.3 °F
- **Heating Flow Rate:** 60 gpm
- **Heating PD - Heat Exchanger:** 6.83 ft
- **Heating PD - Total:** 9.04 ft
- **Heating Ent. / Lv. Water Temp:** 35.0 / 26.2 °F
- **Glycol %:** 20
- **Max Operating Pressure:** 125 psig

### Electrical Data Circuit 1

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<th>Parameter</th>
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### Electrical Data Circuit 2

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<td>Qty</td>
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<tr>
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<td>2 25.00 460 3 1760 34.0</td>
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<tr>
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<td>2 0.25 460 3 1760 0.8</td>
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<td>Control Circuit</td>
<td>1 120 1 1760 2.9</td>
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### Job Information

**Job Name:** NAIC DOAS Unit  
**Site Altitude:** 4850 ft  
**Refrigerant** R-410A

### Static Pressure

- **External:** 3.25 in. wg.  
- **Evaporator:** 0.22 in. wg.  
- **Filters Clean:** 0.21 in. wg.  
- **Dirt Allowance:** 0.75 in. wg.

### Cooling Section

- **Total Capacity:** 304.33 MBH  
- **Sensible Capacity:** 304.33 MBH  
- **Latent Capacity:** 0.00 MBH  
- **Mixed Air Temp:** 82.50 °F DB / 59.70 °F WB  
- **Entering Air Temp:** 82.50 °F DB / 59.70 °F WB  
- **Lv Air Temp (Coil):** 68.73 °F DB / 54.99 °F WB  
- **Lv Air Temp (Unit):** 70.76 °F DB / 55.71 °F WB  
- **Supply Air Fan:** 2 x 300 @ 18.76 BHP Ea.  
- **Evaporator Coil:** 50.6 ft² / 2 Rows / 10 FPI  
- **Evaporator Face Velocity:** 494.5 fpm

### Water Side Performance:

- **Cooling Flow Rate:** 60 gpm  
- **Cooling PD - Heat Exchanger:** 6.83 ft  
- **Cooling PD - Total:** 9.04 ft  
- **Cooling Ent. / Lv. Water Temp:** 90 °F / 103.3 °F  
- **Heating Flow Rate:** 60 gpm  
- **Heating PD - Heat Exchanger:** 6.83 ft  
- **Heating PD - Total:** 9.04 ft  
- **Heating Ent. / Lv. Water Temp:** 35.0 °F / 26.2 °F  
- **Glycol %:** 20  
- **Max Operating Pressure:** 125 psig

### Electrical Data Circuit 1

**Rating:** 460/3/60  
**Minimum Circuit Amp:** 52  
**Maximum Overcurrent:** 70  

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<tr>
<th>Qty</th>
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<th>VAC</th>
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### Electrical Data Circuit 2

**Rating:** 460/3/60  
**Minimum Circuit Amp:** 121  
**Maximum Overcurrent:** 150  

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<td>1760</td>
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<td>120</td>
<td>1</td>
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</table>
Exhaust Fan Model: 300 @ 1205 RPM and 100% Width
Design Conditions: 11000 CFM @ 3.51" SP

Exhaust fan

25,000 cfm at 3.5"
ESP, not including filter fouling pressure
**JOB INFORMATION:**

Job Name: NAIC DOAS Unit  
Job Tag: DOAS-1  
Rep Firm:  
Date: 09/21/2016

**OPERATING CONDITIONS:**

Air Flow: 25,000 CFM  
Static Pressure: 5.75 in. Wg.  
Plenum DP: 0.01 in. Wg.  
Inlet Grill DP: 0.12 in. Wg.  
TSP: 5.88 in. Wg.  
Site Altitude: 4850.00 Ft  
TSP @ Sea Level: 7.03 in. Wg.

**WHEEL SPECIFICATION:**

Max RPM: 1,760  
Diameter x Qty: 30.4 in. x 2  
Width%: 87  
Tip Speed: 13,020 FPM  
Inertia: 90 WR²

**OPERATING CONDITIONS:**

Rated HP / Bypass: 25 x 2 / No  
Frame Size: 284T  
Nominal RPM: 1760  
VAC/PH/HZ: 460/3/60  
Efficiency Premium / 0.936  
Enclosure Type: ODP  
Max Inertial Load: 265 WR²

**FAN PERFORMANCE:**

RPM: 1636  
BHP: 18.76  
Efficiency: 61.8%  
In/Out Velocity: 2104/2765 FPM  
Plenum Out Velocity: 282 FPM

FAN SOUND POWER x 2 Fans (In/Out):  
Octave Band: (Re 10^-12 watts)  
1 95 95 95 94 95 94 90 86  
2 100 99 99 104 104 100 97 91  
SOUND POWER A-Weighted: 100 / 107 dB

**FAN SOUND POWER x 2 Fans (In/Out):**

RPM: 1636  
BHP: 18.76  
Efficiency: 61.76

**SYSTEM EFFICIENCY:**

RPM: 1636  
BHP: 18.76  
SYSTEM EFFICIENCY: 61.76

**CFM x 1000:**

Supply Fan Model: 300 @ 1636 RPM and 87% Width  
Design Conditions: 12500 CFM @ 7.03" SP
SECTION 23 73 13 - MODULAR INDOOR CENTRAL-STATION AIR-HANDLING UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Variable-air-volume, single-zone air-handling units.

1.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Air-handling units shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
   1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

1.3 ACTION SUBMITTALS

A. Product Data: For each air-handling unit indicated.
   1. Unit dimensions and weight.
   2. Cabinet material, metal thickness, finishes, insulation, and accessories.
   3. Fans:
      a. Certified fan-performance curves with system operating conditions indicated.
      b. Certified fan-sound power ratings.
      c. Fan construction and accessories.
      d. Motor ratings, electrical characteristics, and motor accessories.
   4. Certified coil-performance ratings with system operating conditions indicated.
   5. Dampers, including housings, linkages, and operators.
   6. Filters with performance characteristics.

B. LEED Submittals:
   1. Product Data for Prerequisite IEQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."
   2. Provide MERV 13 filter information.

1.4 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For air-handling units, accessories, and components, from manufacturer.
1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Source quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.6 EXTRA MATERIALS:

A. Provide new filters at the time of substantial completion.

B. Provide 1 extra set of filters for each unit on site, coordinate storage location with facility staff.

1.7 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of air-handling units and components.

C. ARI Certification: Air-handling units and their components shall be factory tested according to ARI 430, "Central-Station Air-Handling Units," and shall be listed and labeled by ARI.

D. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

E. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

F. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

   1. Aaon..
   2. No Alternates accepted
2.2 UNIT CASINGS

A. General Fabrication Requirements for Casings:

1. Forming: Form walls, roofs, and floors with at least two breaks at each joint.
2. Casing Joints: Sheet metal screws or pop rivets.
3. Sealing: Seal all joints with water-resistant sealant.
4. Factory Finish for Steel and Galvanized-Steel Casings: Apply manufacturer's standard primer immediately after cleaning and pretreating.
5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

B. Casing Insulation and Adhesive:

1. Materials: ASTM C 1071, Type I.
2. Location and Application: Factory applied with adhesive and mechanical fasteners to the internal surface of section panels downstream from, and including, the cooling-coil section.
   a. Liner Adhesive: Comply with ASTM C 916, Type I.
   b. 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 cabinet.
   c. Liner materials applied in this location shall have air-stream surface coated with a temperature-resistant coating or faced with a plain or coated fibrous mat or fabric depending on service-air velocity.
3. Location and Application: Encased between outside and inside casing.

C. Inspection and Access Panels and Access Doors:

1. Panel and Door Fabrication: Formed and reinforced, double-wall and insulated panels of same materials and thicknesses as casing.
2. Inspection and Access Panels:
   a. Fasteners: Two or more camlock type for panel lift-out operation. Arrangement shall allow panels to be opened against air-pressure differential.
   b. Gasket: Neoprene, applied around entire perimeters of panel frames.
   c. Size: Large enough to allow inspection and maintenance of air-handling unit's internal components.
3. Access Doors:
   a. Hinges: A minimum of two ball-bearing hinges or stainless-steel piano hinge and two wedge-lever-type latches, operable from inside and outside. Arrange doors to be opened against air-pressure differential.
   b. Gasket: Neoprene, applied around entire perimeters of panel frames.
   c. Fabricate windows indoors of double-glazed, wire-reinforced safety glass with an air space between panes and sealed with interior and exterior rubber seals.
   d. Size: At least 18 inches wide by full height of unit casing up to a maximum height of 60 inches.
4. Locations and Applications:
   a. Fan Section: Doors.
b. Access Section: Doors.
c. Coil Section: Inspection and access panel.
d. Damper Section: Doors.
e. Filter Section: Doors large enough to allow periodic removal and installation of filters.
f. Mixing Section: Doors.

5. Service Light: 100-W equivalent vaporproof LED fixture with switched junction box located outside adjacent to door.
   a. Locations: Fan section.

D. Condensate Drain Pans:

1. Fabricated with one percent slope in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and from humidifiers and to direct water toward drain connection.
   a. Length: Extend drain pan downstream from leaving face to comply with ASHRAE 62.1.
   b. Depth: A minimum of 2 inches deep.

2. Stainless-steel - Double sloped.

3. Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on one end of pan.

4. Units with stacked coils shall have an intermediate drain pan to collect condensate from top coil.

E. Air-Handling-Unit Mounting Frame: Formed galvanized-steel channel or structural channel supports, designed for low deflection, welded with integral lifting lugs.

1. Seismic Fabrication Requirements: Fabricate mounting base and attachment to air-handling unit sections, accessories, and components with reinforcement strong enough to withstand seismic forces defined in Section 23 05 48 "Vibration and Seismic Controls for HVAC" when air-handling unit frame is anchored to building structure.

2.3 FAN, DRIVE, AND MOTOR SECTION

A. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower.

1. Shafts: Designed for continuous operation at maximum-rated fan speed and motor horsepower, and with field-adjustable alignment.
   a. Turned, ground, and polished hot-rolled steel with keyway. Ship with a protective coating of lubricating oil.
   b. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.

B. Plenum Fan Housings: Steel frame and panel; fabricated without fan scroll and volute housing.
C. Backward-Inclined, Centrifugal Fan Wheels: Single-width-single-inlet and double-width-double-inlet construction with curved inlet flange, backplate, backward-inclined blades welded or riveted to flange and backplate; cast-iron or cast-steel hub riveted to backplate and fastened to shaft with set screws.

D. Fan Shaft Bearings:
   1. Prelubricated and Sealed, Ball Bearings: Self-aligning, pillow-block type with a rated life of 120,000 hours according to ABMA 9.

E. Belt Drives: Factory mounted, with adjustable alignment and belt tensioning, and with 1.5 service factor based on fan motor.
   1. Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
   2. Motor Pulleys: Adjustable pitch for use with 5-hp motors and smaller; fixed pitch for use with motors larger than 5 hp. Select pulley size so pitch adjustment is at the middle of adjustment range at fan design conditions.
   3. Belts: Oil resistant, nonsparking, and nonstatic; in matched sets for multiple-belt drives.
   4. Belt Guards: Comply with requirements specified by OSHA and fabricate according to SMACNA's "HVAC Duct Construction Standards"; 0.1046-inch-thick, 3/4-inch diamond-mesh wire screen, welded to steel angle frame; prime coated.

F. Internal Vibration Isolation and Seismic Control: Fans shall be factory mounted with manufacturer’s standard restrained vibration isolation mounting devices having a minimum static deflection of 1 inch.
   1. Seismic Fabrication Requirements: Fabricate fan section, internal mounting frame and attachment to fans, fan housings, motors, casings, accessories, and other fan section components with reinforcement strong enough to withstand seismic forces defined in Section 23 05 48 "Vibration and Seismic Controls for HVAC" when fan-mounting frame and air-handling-unit mounting frame are anchored to building structure.

G. Motor: Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 23 05 13 "Common Motor Requirements for HVAC Equipment."
   1. Electrically Commutated Motors (ECM).
   2. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
   4. Mount unit-mounted disconnect switches on exterior of unit.

2.4 COIL SECTION

A. General Requirements for Coil Section:
   1. Comply with ARI 410.
   2. Fabricate coil section to allow removal and replacement of coil for maintenance and to allow in-place access for service and maintenance of coil(s).
   3. For multizone units, provide air deflectors and air baffles to balance airflow across coils.
   4. Coils shall not act as structural component of unit.
   5. Seismic Fabrication Requirements: Fabricate coil section, internal mounting frame and attachment to coils, and other coil section components with reinforcement strong enough to withstand seismic forces defined in Section 23 05 48 "Vibration and Seismic Controls for HVAC"
when coil-mounting frame and air-handling-unit mounting frame are anchored to building structure.
   a. Airflow proving switch.

2.5 INTEGRATED GEOTHERMAL HEAT PUMP
   A. Provide geothermal heat pump factory system to provide heating and cooling utilizing R410A refrigerant.
   B. Compressors to be inverter duty scroll compressors.
   C. Factory accessories to include filter drier, sight glass, and compressor isolation valves.

2.6 HEAT WHEEL
   A. Provide factory installed heat wheel.
   B. See Section 23 72 00 for requirements of heat wheel.

2.7 AIR FILTRATION SECTION
   A. General Requirements for Air Filtration Section:
      1. Comply with NFPA 90A.
      2. Provide minimum arrestance according to ASHRAE 52.1, and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
      3. Provide filter holding frames arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lifted out from access plenum.
   B. Extended-Surface, Disposable Panel Filters:
      1. Factory-fabricated, dry, extended-surface type.
      2. Thickness: 4 inches.
      4. Media: Fibrous material formed into deep-V-shaped pleats and held by self-supporting wire grid.
      7. Provide room for MERV 8 pre-filter
   C. Filter Gage:
      1. 3-1/2-inch- diameter, diaphragm-actuated dial in metal case.
      2. Vent valves.
      3. Black figures on white background.
      4. Front recalibration adjustment.
      5. 3 percent of full-scale accuracy.
      6. Range: 0- to 2.0-inch wg.
      7. Accessories: Static-pressure tips with integral compression fittings, 1/4-inch plastic tubing, and 2- or 3-way vent valves.
2.8 DAMPERS

A. General Requirements for Dampers: Leakage rate, according to AMCA 500, "Laboratory Methods for Testing Dampers for Rating," shall not exceed 2 percent of air quantity at 2000-fpm face velocity through damper and 4-inch wg pressure differential.

B. Damper Operators: Comply with requirements in Section 23 09 23.12 "Control Dampers."

C. Electronic Damper Operators:
   1. Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.
   2. Electronic damper position indicator shall have visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.
   3. Operator Motors:
      a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 23 05 13 "Common Motor Requirements for HVAC Equipment."
      b. Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.
      c. Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.
   4. Nonspring-Return Motors for Dampers Larger Than 25 Sq. Ft.: Size for running torque of 150 in. x lbf and breakaway torque of 300 in. x lbf.
   5. Spring-Return Motors for Dampers Larger Than 25 Sq. Ft.: Size for running and breakaway torque of 150 in. x lbf.
   6. Size dampers for running torque calculated as follows:
      b. Opposed-Blade Damper with Edge Seals: 5 inch-lb/sq. ft. of damper.
      c. Parallel-Blade Damper without Edge Seals: 4 inch-lb/sq. ft. of damper.
      d. Opposed-Blade Damper without Edge Seals: 3 inch-lb/sq. ft. of damper.
      e. Dampers with 2- to 3-Inch wg of Pressure Drop or Face Velocities of 1000 to 2500 fpm: Increase running torque by 1.5.
      f. Dampers with 3- to 4-Inch wg of Pressure Drop or Face Velocities of 2500 to 3000 fpm: Increase running torque by 2.0.
   8. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
   10. Temperature Rating: Minus 22 to plus 122 deg F.
   11. Run Time: 12 seconds open, 5 seconds closed.

D. Outdoor- and Return-Air Mixing Dampers: Parallel-blade, aluminum dampers mechanically fastened to cadmium-plated steel operating rod in reinforced cabinet. Connect operating rods with common linkage and interconnect linkages so dampers operate simultaneously.

E. Mixing Section: Multiple-blade, air-mixer assembly located immediately downstream of mixing section.

F. Combination Filter and Mixing Section:
1. Cabinet support members shall hold 2-inch-thick, pleated, flat, permanent or throwaway filters.
2. Multiple-blade, air-mixer assembly shall mix air to prevent stratification, located immediately downstream of mixing box.

2.9 CONTROLS
A. Provide terminal strips and connections for field.

2.10 CAPACITIES AND CHARACTERISTICS
A. See Schedule on Drawings.

2.11 SOURCE QUALITY CONTROL
A. Fan Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Fans shall bear AMCA-certified sound ratings seal.
B. Fan Performance Rating: Factory test fan performance for airflow, pressure, power, air density, rotation speed, and efficiency. Rate performance according to AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating."
C. Water Coils: Factory tested to 300 psig according to ARI 410 and ASHRAE 33.
D. Refrigerant Coils: Factory tested to 450 psig according to ARI 410 and ASHRAE 33.

PART 3 - EXECUTION

3.1 INSTALLATION
A. Equipment Mounting:
1. Install air-handling units on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 03 30 53 "Miscellaneous Cast-in-Place Concrete."
2. Comply with requirements for vibration isolation and seismic control devices specified in Section 23 05 48 "Vibration and Seismic Controls for HVAC."
3. Comply with requirements for vibration isolation devices specified in Section 23 05 48.13 "Vibration Controls for HVAC."
B. Arrange installation of units to provide access space around air-handling units for service and maintenance.
C. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing, with new, clean filters.
D. Provide new filters at the time of substantial completion.
E. Install filter-gage, static-pressure taps upstream and downstream of filters. Mount filter gages on outside of filter housing or filter plenum in accessible position. Provide filter gages on filter banks, installed with separate static-pressure taps upstream and downstream of filters.

F. Comply with requirements for piping specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

G. Install piping adjacent to air-handling unit to allow service and maintenance.

H. Connect piping to air-handling units mounted on vibration isolators with flexible connectors.

I. Connect condensate drain pans using NPS 1-1/4, ASTM B 88, Type M copper tubing. Extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.

J. Hot- and Heat Pump Piping: Comply with applicable requirements in Section 23 21 13 "Hydronic Piping" and Section 23 21 16 "Hydronic Piping Specialties." Section 15179 "Hydronic Piping Specialties." Install shutoff valve and union or flange at each coil supply connection. Install balancing valve and union or flange at each coil return connection.

K. Refrigerant Piping: Comply with applicable requirements in Section 23 23 00 "Refrigerant Piping." Install shutoff valve and union or flange at each supply and return connection.

L. Connect duct to air-handling units with flexible connections. Comply with requirements in Section 23 33 00 "Air Duct Accessories."

3.2 STARTUP

A. Engage manufacturer representative for start-up on units. Start-up per manufacturer's recommendations.

B. TC to be on site for startup.

PART 4 - PROCUREMENT

A. Contract Vemco Inc. for final pricing to be included in bid for this equipment.

PART 5 - SHOP DRAWINGS

A. See proposed shop drawings in this section. Final shop drawing approval by the engineer is pending.

END OF SECTION 23 73 13
### Job Information

- **Job Name:** NAIC AHU-1
- **Job Number:** 010516
- **Site Altitude:** 4793 ft
- **Refrigerant:** R-410A

### Static Pressure

- **External:** 1.50 in. wg.
- **Evaporator:** 0.42 in. wg.
- **Filters Clean:** 0.29 in. wg.
- **Dirt Allowance:** 0.15 in. wg.

### Cooling Section

<table>
<thead>
<tr>
<th>Gross</th>
<th>Net</th>
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<tbody>
<tr>
<td>195.35</td>
<td>179.70 MBH</td>
</tr>
<tr>
<td>178.56</td>
<td>162.94 MBH</td>
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<tr>
<td>16.76 MBH</td>
<td></td>
</tr>
<tr>
<td>76.16 °F DB</td>
<td>58.11 °F WB</td>
</tr>
<tr>
<td>76.16 °F DB</td>
<td>58.11 °F WB</td>
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<tr>
<td>45.46 °F DB</td>
<td>45.22 °F WB</td>
</tr>
<tr>
<td>48.08 °F DB</td>
<td>46.36 °F WB</td>
</tr>
</tbody>
</table>

- **Supply Air Fan:** 2 x 450 AZ @ 2.70 BHP Ea.
- **SA Fan RPM / Width:** 2117 / 8.030"
- **Evaporator Coil:** 17.3 ft² / 6 Rows / 12 FPI
- **Evaporator Face Velocity:** 376.8 fpm

### Heating Section

- **Primary Heat Type:** Heat Pump
  - **Total Capacity:** 184.2 MBH
  - **RA Temp:** 70.0 °F DB / 54.0 °F WB
  - **Entering Air Temp:** 67.6 °F DB / 48.9 °F WB
  - **Leaving Air Temp:** 98.8 °F DB / 60.2 °F WB
  - **Heating CFM:** 6500
  - **Fan Temp Rise:** 1.9 °F

- **Auxiliary Heat Type:** Hot Water Heat
  - **Heating CFM:** 6500
  - **Total Capacity:** 218.0 MBH
  - **OA Temp:** -25.0 °F DB / -25.0 °F WB
  - **RA Temp:** 70.0 °F DB / 54.0 °F WB
  - **Entering Air Temp:** 33.1 °F DB / 32.2 °F WB
  - **Leaving Air Temp:** 67.6 °F DB / 48.4 °F WB
  - **Entering Glycol:** 130.0 °F
  - **Leaving Glycol:** 119.7 °F
  - **GPM / Head:** 45 / 4.1 ft
  - **Glycol % / Water Velocity:** 35 / 3.54 fps
  - **FA / RD / FPI / FV:** 17.57 ft² / 1 / 12 / 370.0

### Water Side Performance

- **Cooling GPM / Gly. PD:** 45 / 5.86 ft
- **Cooling Ent. / Lv. Gly. Temp:** 90 / 101.9 °F
- **Heating GPM / Gly. PD:** 45 / 5.86 ft
- **Heating Ent. / Lv. Gly. Temp:** 35 / 28.6 °F
- **Glycol %:** 35

### Electrical Data

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<th>VAC</th>
<th>Phase</th>
<th>RPM</th>
<th>FLA</th>
<th>RLA</th>
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<td>460</td>
<td>3</td>
<td>2750</td>
<td>8.3</td>
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<tr>
<td>Supply Fan:</td>
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<td>4.00</td>
<td>460</td>
<td>3</td>
<td>2040</td>
<td>4.9</td>
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<tr>
<td>Exhaust Fan:</td>
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<td>0.25</td>
<td>460</td>
<td>1</td>
<td>850</td>
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**Date Printed:** 10/5/2016 2:07:50 PM
Job Name: NAIC AHU-1
Job Number: 010516
Site Altitude: 4793'

Energy Recovery Type: Total
Energy Recovery Model: ERC-5874C
Energy Recovery Qty: 1

Summer Conditions

Mixed Air
6500 CFM
76.16 °F DB
59.06 °F WB
63.69 gr/lb

Energy Recovery
77.98 °F DB
59.70 °F WB

Supply Air
2525 CFM

Damper

Return Air
3975 CFM
75.00 °F DB
59.00 °F WB

Exhaust Air
2525 CFM
91.00 °F DB
61.00 °F WB
48.03 gr/lb

Ex Bypass: 0 CFM

Cooling/Dehumidification

Total Capacity: 10.65 MBH
Sensible Capacity: 30.15 MBH
Latent Capacity: 0.00 MBH

Heating/Humidification

Total Capacity: 0.00 MBH
Sensible Capacity: 0.00 MBH
Latent Capacity: 19.50 MBH

Winter Conditions

Mixed Air
6500 CFM
65.30 (63.93) °F DB
57.91 (54.38) °F WB
44.23 (43.34) gr/lb

Energy Recovery
57.91 (54.38) °F DB
46.26 (44.09) °F WB

Supply Air
2525 CFM

Damper

Return Air
3975 CFM
70.00 °F DB
54.00 °F WB

Exhaust Air
2525 CFM
17.09 °F DB
16.58 °F WB

Cooling/Dehumidification

Total Capacity: 0.00 (0.00) MBH
Sensible Capacity: 0.00 (0.00) MBH
Latent Capacity: 0.00 (0.00) MBH

Heating/Humidification

Total Capacity: 170.93 (159.54) MBH
Sensible Capacity: 121.40 (113.30) MBH
Latent Capacity: 49.54 (46.23) MBH

() Time Average Performance Due to Energy Recovery Defrost.
JOB INFORMATION:
Job Name: NAIC AHU-1
Job Tag: AHU# 1 (SFan)
Rep Firm: 815
Date: 09/12/2016

OPERATING CONDITIONS:
Air Flow: 6,500 CFM
Static Pressure: 2.88 in. Wg.
Relief Dampers DP: 0.00 in. Wg.
TSP: 2.88 in. Wg.
Site Altitude: 4793.00 Ft
TSP @ Sea Level: 3.44 in. Wg.

FAN PERFORMANCE:
RPM: 2024
BHP: 2.43
Efficiency: 60.6%
In/Out Velocity: 2211/2305 FPM
Plenum Out Velocity: 75 FPM
Max Duct SP with Blocked Airway: 4.2 in. Wg. @ 2024 rpm

WHEEL SPECIFICATION:
Max RPM: 2,750
Diameter x Qty: 17.8 in. x 2
CFM: 3250
Tip Speed: 9,448 FPM
Inertia: 3 WR^2

MOTOR SELECTION:
Rated HP / Bypass: 8 x 2 / No
Frame Size: ECM
Nominal RPM: 2750
VAC/PH/HZ: 460/3/60
Efficiency: Premium / 0.91
Enclosure Type: ODP
Max Inertial Load: 64 WR^2

FAN SOUND POWER x 2 Fans (In/Out):
Octave Band: (Re 10^-12 watts)
1 2 3 4 5 6 7 8
73 76 83 78 78 77 72 68
76 79 86 87 87 82 77 72
SOUND POWER A-Weighted: 82 / 88 dB

Supply Fan Model: 450AZ @ 2024 RPM and 100% Width
Design Conditions: 3250 CFM @ 3.44" SP

Date Created/Modified: 9/2/2016 2:29:58 PM Using Ver 4.244 (OSN# 0123456)  Date Printed: 9/12/2016 1:47:14 PM
JOB INFORMATION:
Job Name: NAIC AHU-1
Job Tag: AHU# 1 (EFan)
Rep Firm: 815
Date: 09/12/2016

OPERATING CONDITIONS:
Air Flow: 6,500 CFM
Static Pressure: 1.10 in. Wg.
Relief Dampers DP: 0.00 in. Wg.
TSP: 1.10 in. Wg.
Site Altitude: 4793.00 Ft
TSP @ Sea Level: 1.31 in. Wg.

FAN PERFORMANCE:
RPM: 1596
BHP: 1.09
Efficiency: 51.7%
In/Out Velocity: 2211/2305 FPM
Plenum Out Velocity: 73 FPM

WHEEL SPECIFICATION:
Max RPM: 2,750
Diameter x Qty: 17.8 in. x 2
CFM: 3250
Tip Speed: 7,450 FPM
Inertia: 3 WR²

MOTOR SELECTION:
Rated HP / Bypass: 8 x 2 / No
Frame Size: ECM
Nominal RPM: 2750
VAC/PH/HZ: 460/3/60
Efficiency: Premium / 0.91
Enclosure Type: ODP
Max Inertial Load: 64 WR²

FAN SOUND POWER x 2 Fans (In/Out):
Octave Band: (Re 10⁻¹² watts)
1  2  3  4  5  6  7  8
75 78 76 74 74 74 75 76
75 78 81 84 81 79 76 72
SOUND POWER A-Weighted: 82 / 85 dB

Exhaust Fan Model: 450AZ @ 1596 RPM and 90% Width
Design Conditions: 3250 CFM @ 1.31" SP
NOTE:
UNIT SHALL BE SHIPPED AS THREE (3) SECTIONS:

SECTION I: EFAN & HEAT WHEEL
SECTION II: FILTER & BLANK BOX
SECTION III: V3E & WSHP
M 3 - 0 - 0 6 0 - 1 0 8 x 0 9 9 - 3 - A - A - 0 - B - 0 - 0
Tag: ECON-1

**Job Information**

- **Job Name:** NAIC
- **Job Number:** Job #184
- **Site Altitude:** 4793 ft
- **Unit Foot Print (W x L):** 118” x 168”

**Unit Static Pressure**

- **External:** 3.25 in. wg.
- **Dirt Allowance:** 0.35 in. wg.
- **Total:** 5.02 in. wg.

**Components Static Pressure**

- 101-OA Opening 0.32
- 102-4” cartridge Filter 0.58
- 102-Pleated Filter 0.44
- 105-Discharge Opening 0.08

**Cooling Section**

- **Total Capacity:**
- **Sensible Capacity:**
- **Latent Capacity:**
- **Mixed Air Temp:**
- **Entering Air Temp:**
- **Lv Air Temp (Coil):**
- **Lv Air Temp (Unit):**

**Heating Section**

- **No Heating**

**EER - ARI Listing Information**

*No ARI Rating Program Exists for Non-Compressorized Units.  All AAON Units Are Tested in Accordance With ARI Standards*

**Electrical Data**

- **Rating:** 460/3/60
- **Unit FLA:** 84
- **Qty:** 4
- **HP:** 15.00
- **VAC:** 460
- **Phase:** 3
- **RPM:** 1760
- **FLA:** 21.0
- **RLA:**
- **Minimum Circuit Amp:** 89
- **Maximum Overcurrent:** 110

**Cabinet Sound Power Levels**

- **Octave Bands LW (dB):** 63 125 250 500 1000 2000 4000 8000
- **Mod# 105 - Discharge-End Opening:** 102 100 100 105 103 101 101 97
- **Mod# 101 - Intake-End Opening:** 100 98 97 95 93 91 82 80

*Sound power levels are given for informational purposes only. The sound levels are not guaranteed.*
JOB INFORMATION:
Job Name: NAIC
Job Tag: ECON-1
Rep Firm: 815
Date: 09/20/2016

OPERATING CONDITIONS:
Air Flow: 39,000 CFM
Static Pressure: 5.02 in. Wg.
Plenum DP: 0.00 in. Wg.
Inlet Grill DP: 0.00 in. Wg.
TSP: 5.02 in. Wg.
Site Altitude: 4793.00 Ft
TSP @ Sea Level: 5.99 in. Wg.

FAN PERFORMANCE:
RPM: 1672
BHP: 12.03
Efficiency: 64.1%
In/Out Velocity: 2546/2664 FPM
Plenum Out Velocity: 440 FPM
Max Duct SP with VFD Bypass Enabled: 7.2 in. Wg. @ 1760 rpm
Max Duct SP with Blocked Airway: 6.5 in. Wg. @ 1672 rpm

WHEEL SPECIFICATION:
Max RPM: 1,760
Diameter x Qty: 27.4 in. x 4
Width%: 92
Tip Speed: 11,994 FPM
Inertia: 16 WR²

MOTOR SELECTION:
Rated HP / Bypass: 15 x 4 / Yes*
Frame Size: 254T
Nominal RPM: 1760
VAC/PH/HZ: 460/3/60
Efficiency: Premium / 0.93
Enclosure Type: ODP
Max Inertial Load: 149 WR²
*Please Contact Factory.

FAN SOUND POWER x 4 Fans (In/Out):
Octave Band: (Re 10^4-12 watts)
1 2 3 4 5 6 7 8
100 98 97 95 93 95 95 94
102 100 100 105 103 101 101 97

SOUND POWER A-Weighted: 103 / 108 dB

Supply Fan Model: 270 @ 1672 RPM and 92% Width
Design Conditions: 9750 CFM @ 5.99" SP
### Base Option

<table>
<thead>
<tr>
<th>Option</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>M</td>
<td>Series Air Handling Unit</td>
</tr>
<tr>
<td>3</td>
<td>Generation 3rd Generation</td>
</tr>
<tr>
<td>0</td>
<td>Type Indoor Unit</td>
</tr>
<tr>
<td>060</td>
<td>Unit Size 60 sq ft coil</td>
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<tr>
<td>108x099</td>
<td>Cross Section ID - Width x Height (inches) 108” wide by 99” tall</td>
</tr>
<tr>
<td>3</td>
<td>Voltage 460V/3Ø/60 Hz</td>
</tr>
<tr>
<td>A</td>
<td>Assembly Factory assembled</td>
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<tr>
<td>A</td>
<td>Wiring Wiring / motor starters / branch fusing</td>
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<tr>
<td>0</td>
<td>Accessories None</td>
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<td>Corrosion Protection Painted exterior</td>
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<td>Base Rail 6” High</td>
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### Module Configuration

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<th>Module Type</th>
<th>Module Configuration</th>
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<tr>
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<td>MBA-101-A-00-F00A0-00000-0-0</td>
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<tr>
<td>Flat cartridge filter bank</td>
<td>FMC-102-0-00-AABB0-00000-0-0</td>
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<td>2' access section</td>
<td>BMA-103-A-00-00000-00000-0-0</td>
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<tr>
<td>Supply fan w/ external control panel</td>
<td>SFC-104-B-AA-CGTAC-00DAL-0-0</td>
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<td>Discharge plenum</td>
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### MBA - 1 0 1 - A - 0 0 - F 0 0 A 0 - 0 0 0 0 - 0 - 0

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<th>Job Name: NAIC</th>
<th>Unit Tag: ECON-1</th>
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<tbody>
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<td>Supply CFM</td>
<td>MA DB °F</td>
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<tr>
<td>Summer</td>
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<tr>
<td>Winter</td>
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#### Module Option

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<td>Connections</td>
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<td>F</td>
<td>Outside Air Location</td>
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<td>Return Air Location</td>
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<td>Exhaust Air Location</td>
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### FMC - 1 0 2 - 0 - 0 0 - A A B B 0 - 0 0 0 0 0 - 0 - 0

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<th>AIR PD (In.)</th>
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#### Module Option

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<td>A</td>
<td>Pre-filter Type</td>
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<td>Final Filter Type</td>
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<td>B</td>
<td>Final Filter Efficiency</td>
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### BM A - 1 0 3 - A - 0 0 - 0 0 0 0 0 - 0 0 0 0 - 0 0

#### Job Name: NAIC  
#### Unit Tag: ECON-1

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<th>Entering Air WB (ºF)</th>
<th>Leaving Air DB (ºF)</th>
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**Module Option**
- **BMA**: Module ID  
  **103**: Position  
  **A**: Compartment Pressurization  
  **0**: Blank  
  **0**: Blank  
  **0**: Drain Pan  
  **0**: Blank  
  **0**: Blank  
  **0**: Blank  
  **0**: Blank  
  **0**: Module Accessories  
  **0**: Access  
  **0**: Special

**Description**
- 2' access section  
- First level - position three  
- Draw thru / no end wall

### S F C - 1 0 4 - B - A A - C G T A C - 0 0 D A L - 0 - 0

#### Entering Air DB (ºF) | 95  
#### Entering Air WB (ºF) | 64  
#### Leaving Air DB (ºF) | 98.11  
#### Leaving Air WB (ºF) | 64.91  
#### Module PD | 5.02

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**Module Option**
- **SFC**: Module ID  
- **104**: Position  
- **B**: Connections  
- **A**: Controls - Type  
- **A**: Controls - Manufacturer  
- **C**: Blowers and Motors - Quantity  
- **G**: Blowers and Motors - Type  
- **T**: Blowers and Motors - HP  
- **A**: Blowers and Motors - Blower  
- **C**: Blowers and Motors - Isolation  
- **0**: Filters Type  
- **D**: Power Switch  
- **A**: Control Panel / Opening  
- **L**: Module Accessories  
- **0**: Access  
- **0**: Special

**Description**
- Supply fan w/ external control panel  
- First level - position four  
- Air leaving side end wall  
- Terminal strip for field controls  
- Wiring to terminal strip  
- 4 Blowers w/ ODP motors  
- Premium w/ 2 VFD's and bypass  
- 15 hp (1760 rpm)  
- 27" diameter  
- Springs (Seismic 2" deflection)  
- None  
- 150A non-fused disconnect  
- Left control panel  
- Marine light / door window  
- Left door / no drain  
- None
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SECTION 23 81 46.13 - WATER-TO-AIR HEAT PUMPS

PART 1 - GENERAL

1.1 SUMMARY
A. Section Includes:
   1. Concealed horizontal or vertical units, 6 tons and smaller.
   2. Exposed, floor-mounted console units.

1.2 ACTION SUBMITTALS
A. Product Data: For each type of product.

B. LEED Submittals:
   1. Product Data for Credit EA 4: Documentation indicating that equipment and refrigerants comply.
   2. Product Data for Prerequisite IEQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."

C. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   1. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS
A. Field quality-control reports.

B. Sample Warranty: For special warranty.

1.4 CLOSEOUT SUBMITTALS
A. Operation and maintenance data

1.5 QUALITY ASSURANCE
A. ASHRAE Compliance:
   1. ASHRAE 15.
   2. Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

B. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
C. Comply with NFPA 70.

D. Comply with safety requirements in UL 484 for assembly of free-delivery, water-source heat pumps.

E. Comply with safety requirements in UL 1995 for duct-system connections.

1.6 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of water-source heat pumps that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, refrigeration components.
2. Warranty Period: Five years from date of Substantial Completion.

1.7 EXTRA MATERIALS:

A. Provide new filters at the time of substantial completion.

B. Provide 1 extra set of filters for each unit on site, coordinate storage location with facility staff.

PART 2 - PRODUCTS

2.1 CONCEALED WATER-SOURCE HEAT PUMPS, 6 TONS AND SMALLER

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

1. Aaon.
2. No alternates accepted

B. Description: Packaged water-source heat pump with temperature controls; factory assembled, tested, and rated according to ASHRAE/ARI/ISO-13256-1.

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a testing agency acceptable to authorities having jurisdiction, and marked for intended location and application.

C. General Description

1. Water-Source Heat Pump unit shall include compressor, DX air coil, coaxial refrigerant-to-water heat exchanger, filters, supply fan, and unit controls.
2. Unit shall be factory assembled and tested including leak testing of the coil, pressure testing of the refrigeration circuit, and run testing of the completed unit. Run test report shall be available in an electronic format.
3. Unit shall have decals and tags to indicate caution areas for safety as required by codes.
4. User’s manual shall be supplied within the unit.
5. Color-coded wiring diagram shall match factory installed wiring and shall be affixed to the interior of the control compartment’s access panel.
6. Unit nameplate shall be affixed to the exterior of the unit.

D. Construction
1. Horizontal units shall have right or left intake, draw-through supply fan, and left or right or end discharge. Unit shall have the ability to be field convertible between side and end discharge.
2. All cabinet walls shall be fabricated of aluminum with 1 inch foil faced cotton insulation. Unit insulation shall have a minimum thermal resistance R-value of 4.
3. Access to air filters, compressor, air coil, refrigerant-to-water heat exchanger, supply fan and electrical and controls components shall be through removable toolless side access panels.
4. Horizontal units shall have access to air filters, expansion valve, filter drier, reversing valve, supply fan and motor through removable bottom access panels.
5. Unit shall be designed with wrench-less flush mounted water connections.
6. Horizontal units shall have integrated hanging brackets with rubber vibration isolation.
7. Unit shall include a 304 stainless steel sloped drain pan. Drain pan connection shall be available on the right (left) side of the air handling section of the unit.
8. Unit shall have ½ inch supply duct flange.
9. Low sound package shall include compressor sound blanket and 1 inch foil faced cotton insulation on the blower housing.

E. Electrical
1. Unit shall be provided with an integrated control panel and compressor contactor for connecting power to the unit.
2. Control circuit transformer and wiring shall provide 24 VAC control voltage from the line voltage to the unit.
3. Units shall be provided with factory installed and factory wired non-fused disconnect. Switch shall be accessible from the exterior of the unit.
4. Unit shall be provided with phase and brownout protection module that shuts down all motors in the unit if the electrical phases are more that 8% out of balance on voltage, the voltage is more that 8% under design voltage, or on phase reversal.

F. Supply Fans
1. Unit shall include direct drive forward curved centrifugal blower.
2. Unit shall include Electronically Commutated Motor (ECM) driven supply fan with thermal overload protection. Supply fan shall include isolator between the fan and cabinet to reduce unit vibration.

G. DX Air Coil
1. DX Air Coil
   a. Coil shall be designed for use with R-410A refrigerant and shall be fabricated from aluminum microchannel tubes.
   b. Coil shall be designed for a minimum of 6°F of refrigerant subcooling.
   c. Coil shall be leak tested.
   d. Coil shall be furnished with a thermostatic expansion valve.
   e. Drain pan shall be provided with overflow switch which shuts down the compressor when overflow of the unit drain pan is detected.

H. Refrigeration System
1. Unit shall be factory charged with R-410A refrigerant.
2. Compressors of 2 ton (24 MBH) and larger units shall be R-410A scroll type with thermal overload protection and independently circuited.
3. Compressors of ½ - 1½ ton (6 - 18 MBH) units shall be R-410A rotary type with thermal overload protection and independently circuited.
4. Compressor shall carry a 5 year non-prorated warranty, from the date of equipment manufacture.
5. Compressors shall be isolated from compressor mounting plate with the compressor manufacturer’s recommended rubber vibration isolators and compressor mounting plate shall be isolated from the cabinet with rubber vibration isolator, to reduce any transmission of noise from the compressor into the building area.

6. Unit shall be equipped with thermostatic expansion valve type refrigerant flow control.

7. Unit shall be configured as a geothermal water-source heat pump. Unit shall be equipped with an automatic reset low pressure and high pressure refrigerant safety controls, Schrader type service fittings on both the high pressure and low pressure sides, factory installed liquid line heat pump filter drier, reversing valve, and thermostatic expansion valve. Reversing valve shall energize during the cooling mode of operation.

I. Coaxial Heat Exchanger

1. Coaxial Heat Exchanger
   
   a. All field installed piping shall be hydrostatically tested before being put into service. Test pressure shall be 125 psi for a two hour duration. Leaks and loss in test pressure constitute defects. If test fails, corrections shall be made to the system and the test shall then be repeated to make certain all defects were corrected. All testing shall be performed to ASTM Standards.
   
   b. Unit shall contain coaxial tube-in-tube heat exchangers. Heat exchanger shall be circulated in a counter flow heating arrangement to the refrigerant system. Field piping connections shall be labeled wrench-less flush mounted water connections. Maximum operating pressure on the water side of the heat exchanger shall be 400 psi.
   
   c. Unit shall be supplied with Ground/Ground Water Loop extended water temperature range insulation that includes insulation on all water piping and refrigerant suction line.

J. Filters

1. Unit shall include 4 inch thick, pleated panel filters with a MERV rating of 13, upstream of the air coil. Filter rack service access shall be from the side of the unit. Horizontal units shall include side and bottom filter rack service access.

K. Controls

1. Provide Aaon’s factory installed native Bacnet control system. Provide full single zone VAV control.

L. Electrical Connection: Single electrical connection with non-fused disconnect.

M. Capacities and Characteristics:

1. See Schedule on Drawings.

2.2 EXPOSED, CONSOLE WATER-SOURCE HEAT PUMPS (VERTICAL “SB” UNITS)

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

   1. Aaon.
   2. No alternates accepted

B. Description: Packaged water-source heat pump with temperature controls; factory assembled, tested, and rated according to ASHRAE/ARI/ISO-13256-1.
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a testing agency acceptable to authorities having jurisdiction, and marked for intended location and application.

C. General Description

1. Self contained unit shall include compressors, evaporator coils, filters, supply fans, water-cooled condensers, reheat coils, electric heaters, hot water coils, steam coils, and unit controls.
2. Unit shall be factory assembled and tested including leak testing of the coils, pressure testing of the refrigeration circuit, and run testing of the completed unit. Run test report shall be supplied with the unit in the controls compartment's literature pocket.
3. Unit shall have decals and tags to indicate lifting and rigging, service areas, and caution areas for safety and to assist service personnel.
4. Unit components shall be labeled, including (pipe stub outs,) refrigeration system components, and electrical and controls components.
5. Installation, Operation and Maintenance manual shall be supplied within the unit.
6. Laminated color-coded wiring diagram shall match factory installed wiring and shall be affixed to the interior of the control compartment's access door.
7. Unit nameplate shall be provided in two locations on the unit, affixed to the exterior of the unit and affixed to the interior of the control compartment's access door.

D. Construction

1. Unit shall be provided with a horizontal intake, have a draw-through supply fan configuration and discharge air vertically.
2. All cabinet walls and access doors shall be fabricated of double wall, impact resistant, rigid polyurethane foam panels.
3. Unit insulation shall have a minimum thermal resistance R-value of 6.5. Foam insulation shall have a density of 2 pounds/cubic foot and shall be tested in accordance with ASTM D1929 for a minimum flash ignition temperature of 610°F.
4. Unit construction shall be double wall with G90 galvanized steel on both sides and a thermal break. Double wall construction with a thermal break prevents moisture accumulation on the insulation, provides a cleanable interior, prevents heat transfer through the panel, and prevents exterior condensation on the panel.
5. Unit shall be designed to reduce air leakage and infiltration through the cabinet. Sealing shall be included between panels and between access doors and openings to reduce air leakage. Refrigerant piping and electrical wiring through cabinet panels shall include sealing to reduce air leakage.
6. Access to filters, compressors, cooling coil, reheat coil, condensers, heaters, supply fans and electrical and controls components shall be through hinged access doors.
7. Access doors shall be flush mounted to cabinetry, with stainless steel removable pin hinges and zinc cast lockable handles.
8. Unit shall include a 304 stainless steel sloped drain pan. Drain pan connection shall be available on the right (left) side of the air handling section of the unit.
9. Cooling coils shall be mechanically supported above the drain pan by multiple supports that allow drain pan cleaning and coil removal.

E. Electrical

1. Unit shall be provided with an integrated control panel.
2. Unit shall be provided with standard power block for connecting power to the unit.
3. Control circuit transformer and wiring shall provide 24 VAC control voltage from the line voltage to the unit.
4. Unit shall be provided with phase and brownout protection which shuts down all motors in the unit if the electrical phases are more than 10% out of balance on voltage, the voltage is more that 10% under design voltage, or on phase reversal.
5. Unit shall be provided with blower auxiliary contacts on the low voltage terminal block which close when the supply fans are energized.
6. Unit shall be provided with manual reset low temperature limit controls which shut off the unit when the discharge temperature reaches a field adjustable setpoint.

F. Supply Fans
1. Unit shall include direct drive, unhoused, backward curved, plenum supply fans.
2. Fan and motor assembly shall be dynamically balanced.
3. Motors shall be high efficiency electronically commutated motors ECM.
4. Supply air shall discharge vertically from the unit.
   a. ECM driven supply fan speed shall be controlled by the manufacturer’s provided DDC Controller.

G. Cooling Coil
1. Evaporator Coil
   a. Coil shall be designed for use with R-410A refrigerant and constructed of copper tubes with aluminum fins mechanically bonded to the tubes and aluminum (304 stainless steel) end casings. Fin design shall be sine wave rippled.
   b. Coil shall be standard (6 row high) capacity.
   c. Coil shall be hydrogen or helium leak tested.
   d. Coil shall be furnished with a factory installed thermostatic expansion valves.
   e. Drain pan shall be provided with overflow switch which shuts down the cooling circuits when overflow of the unit drain pan is detected.

H. Refrigeration System
1. Unit shall be factory charged with R-410A refrigerant.
2. Compressors shall be R-410A scroll type with thermal overload protection and independently circuited.
3. Unit shall include a variable capacity scroll compressor which shall be capable of modulation from 10-100% of its rated capacity.
4. Compressor shall carry a 5 year non-prorated warranty, from the date of original equipment shipment from the factory.
5. Compressors shall be mounted in an isolated service compartment which can be accessed without affecting unit operation. Lockable hinged compressor access doors shall be fabricated of double wall, rigid polyurethane foam insulated panels to prevent the transmission of noise outside the cabinet.
6. Compressors shall be isolated from unit with the compressor manufacturer’s recommended rubber vibration isolators, to reduce any transmission of noise from the compressor into the building area.
7. Unit shall be equipped with thermostatic expansion valve type refrigerant flow control.
8. Unit shall be configured as a water-source heat pump. Unit shall be equipped with an automatic reset low pressure and manual reset high pressure refrigerant safety controls, Schrader type service fittings on both the high pressure and low pressure sides, factory installed liquid line heat pump filter drier, reversing valve, and thermostatic expansion valves on the indoor coil and refrigerant-to-water heat exchangers. Reversing valve shall energize during the cooling mode of operation.
9. Modulating hot gas reheat shall be provided on the lead refrigeration circuit. Refrigeration circuit shall be provided with hot gas reheat coil, modulating valves, receiver tank, electronic controller, supply air temperature sensor and a dehumidification control signal terminal which allow the unit to have a dehumidification mode of operation, which includes supply air temperature control to prevent supply air temperature swings and overcooling of the space.

10. Each refrigeration circuit shall be equipped with a liquid line sight glass.

11. Each refrigeration circuit shall be equipped with suction and discharge compressor isolation valves.

12. Each refrigeration circuit shall be provided with an adjustable temperature sensor freeze stat which shuts down the cooling circuits when the evaporator coil tubing falls below the setpoint.

I. Condensers

1. Water-Cooled Condenser
   a. All field installed piping shall be hydrostatically tested before being put into service. Test pressure shall be 300 psi for a two hour duration. Leaks and loss in test pressure constitute defects. If test fails, corrections shall be made to the system and the test shall then be repeated to make certain all defects were corrected. All testing shall be performed to ASTM Standards.
   b. Water-cooled condensing section shall contain coaxial tube-in-tube heat exchangers. Heat exchanger shall be circuited in a counter flow arrangement to the refrigerant system. Tubes shall be copper. Field piping connections shall be external to the self-contained unit. Connections shall be labeled, extend beyond the unit casing and be factory sealed to prevent condensation in the panel assembly. Maximum operating pressure on the water side of the condenser shall be 300 psi.
   c. Each heat exchanger circuit shall have a flow switch that shuts down the compressors if water flow to the condenser is interrupted.
   d. Water-cooled condensing section shall contain coaxial tube-in-tube heat exchangers. Heat exchanger shall be circuited in a counter flow arrangement to the refrigerant system. Tubes shall be cupronickel. Field piping connections shall be external to the self-contained unit. Connections shall be labeled, extend beyond the unit casing and be factory sealed to prevent condensation in the panel assembly. Maximum operating pressure on the water side of the condenser shall be 300 psi.
   e. Each heat exchanger circuit shall have a factory installed motorized shutoff valve.
   f. Unit shall include factory installed head pressure control module and each heat exchanger shall include factory installed head pressure control valve which modulates the condenser water flow based on head pressure and allows cooling operation below 65°F condenser water temperature.

J. Heating Coil

1. Hot Water Heating Coil (where indicated on drawing schedule)
   a. Coil shall be certified in accordance with AHRI Standard 410 and be hydrogen or helium leak tested.
   b. Coil shall be constructed of copper tubes with aluminum fins mechanically bonded to the tubes and aluminum end casings. Fin design shall be sine wave rippled.
   c. Coil shall have single serpentine circuitry.
   d. Coil shall have external piping connections. Supply and return connections shall be sweat connection. Coil connections shall be labeled, extent beyond the unit casing and be factory sealed to minimize air leakage and condensation inside the panel assembly.
   e. Coil shall be located in the preheat position upstream of the cooling coil.
   f. Control valves shall be field supplied and field installed.
K. Filters
   1. Unit shall include 4 inch thick, pleated panel filters with a MERV rating of 13, upstream of the heating and cooling coils. Unit shall also include 2 inch thick, pleated panel pre filters with MERV rating of 8, upstream of the 4 inch standard filters.
   2. Unit shall include a clogged filter switch.
   3. Unit shall include factory installed Magnehelic gauge measuring the pressure drop across the filter rack.

L. Controls
   1. Factory Installed and Factory Provided Controller
      a. Unit controller shall be capable of controlling the specified features and options of the unit. Controller shall be factory installed in the unit controls compartment and factory tested.
         1) Control discharge air temperature (VAV units).
         2) Receive and input for fan speed/operation.
         3) Receive and input for heating or cooling.
         4) See 23 09 93 for other requirements.
      b. Controller to be BacNet native or have a BacNet gateway for connection to DDC System.

M. Accessories
   1. Unit shall be provided with a low voltage safety shutdown terminal block for field installation of a smoke detector which shuts off the unit's control circuit.

N. Electrical Connection: Single electrical connection with non-fused disconnect.

O. Capacities and Characteristics:
   1. See Schedule on drawings:

2.3 HOSE KITS
A. General: Hose kits shall be designed for minimum 400-psig working pressure and operating temperatures from 33 to 211 deg F. Tag hose kits to equipment designations.
B. Hose: Length 24 inches braided stainless steel, complete with adapters,. Minimum diameter, equal to water-source, heat-pump connection size.
C. Isolation Valves: Two-piece, bronze-body ball valves with stainless-steel, standard-port ball and stem with normal pipe thread (NPT) connections, and galvanized-steel lever handle. Provide valve for supply and return.
D. Strainer: Y-type with blowdown valve in supply connection.
E. Balancing Device: Mount in return connection. Include meter ports to allow flow measurement with differential pressure gage.
   1. Automatic balancing valve, factory set to operate within 10 percent of design flow rate over a 40:1 differential pressure range of 2 to 80 psig.
F. See details on drawings for all required accessories and components required.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Floor Mounting: Install water-source heat pumps using spring isolators. Comply with requirements for vibration isolation devices specified in Section 23 05 48 "Vibration and Seismic Controls for HVAC Piping and Equipment."

B. Suspended Units: Install water-source heat pumps with continuous-thread hanger rods and spring hangers with vertical-limit stop of size required to support weight of water-source heat pump unit.
   1. Comply with requirements for seismic-restraint devices specified in Section 23 05 48 "Vibration and Seismic Controls for HVAC Piping and Equipment."

C. Install wall-mounting thermostats, humidistats, and switch controls in electrical outlet boxes at heights to match lighting controls or as required in Section 23 09 23.27 "Temperature Instruments," and Section 23 09 23 "Direct Digital Control (DDC) System for HVAC."

D. Connect supply and return hydronic piping to heat pump.

E. Connect heat-pump condensate drain pan to indirect waste connection with condensate trap of adequate depth to seal against fan pressure. Install cleanouts in piping at changes of direction.

F. Connect supply and return ducts to water-source heat pumps with flexible duct connectors specified in Section 23 33 00 "Air Duct Accessories."

G. Install electrical devices furnished by manufacturer but not specified to be factory mounted.

H. Install piping adjacent to machine to allow service and maintenance.

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. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing, with new, clean filters.

L. Provide new filters at the time of substantial completion.

3.2 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections:
   1. After installing water-source heat pumps and after electrical circuitry has been energized, test units for compliance with requirements.
   2. Inspect for and remove shipping bolts, blocks, and tie-down straps.
   3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Heat pumps will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

3.3 STARTUP

A. Engage manufacturer representative for start-up on units. Start-up per manufacturer's recommendations.

B. TC to be on site for startup.

3.4 TRAINING

A. Provide training per 230100.

PART 4 - PROCUREMENT

A. Contract Vemco Inc. for final pricing to be included in bid for this equipment.

PART 5 - SHOP DRAWINGS

A. See proposed shop drawings in this section. Final shop drawing approval by the engineer is pending.

END OF SECTION 23 81 46.13
Tag: HHP-002

(Values do not account for changes described in SPA)

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<td>Supply Air Fan</td>
<td>1 x 987T13EC @ 0.24 BHP Ea.</td>
<td></td>
</tr>
<tr>
<td>SA Fan RPM</td>
<td>775/950/1151 rpm (Low/Med/High)</td>
<td></td>
</tr>
<tr>
<td>Evaporator Coil</td>
<td>2.6 ft²</td>
<td></td>
</tr>
<tr>
<td>Evaporator Face Velocity</td>
<td>307.3 fpm / 800 CFM</td>
<td></td>
</tr>
</tbody>
</table>

Heating Section(**)

<table>
<thead>
<tr>
<th>Section</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary Heat Type:</td>
<td>Heat Pump</td>
</tr>
<tr>
<td>Total Capacity:</td>
<td>21.5 MBH</td>
</tr>
<tr>
<td>RA Temp:</td>
<td>70.0°F DB / 62.00°F WB</td>
</tr>
<tr>
<td>Entering Air Temp:</td>
<td>70.0°F DB / 62.00°F WB</td>
</tr>
<tr>
<td>Leaving Air Temp:</td>
<td>99.6°F DB / 70.38°F WB</td>
</tr>
<tr>
<td>Auxiliary Heat Type:</td>
<td>None</td>
</tr>
<tr>
<td>Heating CFM:</td>
<td>800</td>
</tr>
<tr>
<td>Fan Temp Rise:</td>
<td>1.1°F DB</td>
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Water Side Performance:

<table>
<thead>
<tr>
<th>Performance</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooling GPM / Fluid PD:</td>
<td>6 / 9.19 ft</td>
</tr>
<tr>
<td>Heating GPM / Fluid PD:</td>
<td>6 / 7.98 ft</td>
</tr>
<tr>
<td>Heating Ent. / Lv. Fluid Temp:</td>
<td>35.00 / 29.87 °F</td>
</tr>
<tr>
<td>Fluid:</td>
<td>PropyleneGlycol - 35%</td>
</tr>
<tr>
<td>Max Operating Pressure:</td>
<td>300 psig</td>
</tr>
</tbody>
</table>

Rating Information

<table>
<thead>
<tr>
<th>Type</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Cooling Capacity (MBH):</td>
<td>24.0</td>
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<tr>
<td>Cooling EER:</td>
<td>15.1</td>
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<tr>
<td>Heating High Temp Capacity (MBH):</td>
<td>27.7</td>
</tr>
<tr>
<td>Heating High Temp COP:</td>
<td>5</td>
</tr>
</tbody>
</table>

Rated in accordance with ISO 13256-1

Application EER @ Op. Conditions: 9.7

Application COPH @ Op. Conditions: 3.5

Electrical Data

<table>
<thead>
<tr>
<th>Type</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Rating:</td>
<td>265/1/60</td>
</tr>
<tr>
<td>Unit FLA:</td>
<td>11</td>
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<tr>
<td>Minimum Circuit Amp:</td>
<td>13</td>
</tr>
<tr>
<td>Maximum Overcurrent:</td>
<td>20</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Component</th>
<th>Qty</th>
<th>HP</th>
<th>VAC</th>
<th>Phase</th>
<th>RPM</th>
<th>FLA</th>
<th>RLA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compressor 1:</td>
<td>1</td>
<td>0.33</td>
<td>265</td>
<td>1</td>
<td>3500</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Supply Fan:</td>
<td>1</td>
<td>0.33</td>
<td>265</td>
<td>1</td>
<td>1200</td>
<td>1.9</td>
<td></td>
</tr>
</tbody>
</table>

(**) Fan motor temperature rise is not included in the heat capacity and temps.
Tag: HHP-003

(Values do not account for changes described in SPA)

**Job Information**

<table>
<thead>
<tr>
<th>Field</th>
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<tbody>
<tr>
<td>Job Name:</td>
<td>NAIC</td>
</tr>
<tr>
<td>Job Number:</td>
<td>Job #184</td>
</tr>
<tr>
<td>Site Altitude:</td>
<td>4793</td>
</tr>
</tbody>
</table>

**Static Pressure**

- Max Avail. External: 0.25/0.53/0.86 (Low/Med/High)
- Evaporator: 0.12 in. wg
- Filters Clean:
- Dirt Allowance

**Cooling Section**

<table>
<thead>
<tr>
<th>Field</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross Total Capacity:</td>
<td>28.92 MBH</td>
</tr>
<tr>
<td>Net Total Capacity:</td>
<td>27.57 MBH</td>
</tr>
<tr>
<td>Sensible Capacity:</td>
<td>26.45 MBH</td>
</tr>
<tr>
<td>Latent Capacity:</td>
<td>2.46 MBH</td>
</tr>
<tr>
<td>Mixed Air Temp:</td>
<td>75.00 °F DB / 56.00 °F WB</td>
</tr>
<tr>
<td>Entering Air Temp:</td>
<td>75.00 °F DB / 56.00 °F WB</td>
</tr>
<tr>
<td>Lv Air Temp (Coil):</td>
<td>50.42 °F DB / 48.07 °F WB</td>
</tr>
<tr>
<td>Lv Air Temp (Unit):</td>
<td>51.68 °F DB / 48.59 °F WB</td>
</tr>
<tr>
<td>Supply Air Fan:</td>
<td>1 x 1008T12EC @ 0.42 BHP Ea.</td>
</tr>
<tr>
<td>SA Fan RPM:</td>
<td>800/950/1111 rpm (Low/Med/High)</td>
</tr>
<tr>
<td>Evaporator Coil:</td>
<td>4.0 ft³</td>
</tr>
<tr>
<td>Evaporator Face Velocity:</td>
<td>303.7 fpm / 1200 CFM</td>
</tr>
</tbody>
</table>

**Heating Section**

<table>
<thead>
<tr>
<th>Field</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary Heat Type:</td>
<td>Heat Pump</td>
</tr>
<tr>
<td>Total Capacity:</td>
<td>31.7 MBH</td>
</tr>
<tr>
<td>RA Temp:</td>
<td>70.0°F DB / 62.00°F WB</td>
</tr>
<tr>
<td>Entering Air Temp:</td>
<td>70.0°F DB / 62.00°F WB</td>
</tr>
<tr>
<td>Leaving Air Temp:</td>
<td>99.1°F DB / 70.25°F WB</td>
</tr>
<tr>
<td>Auxiliary Heat Type:</td>
<td>None</td>
</tr>
<tr>
<td>Heating CFM:</td>
<td>1200</td>
</tr>
<tr>
<td>Fan Temp Rise:</td>
<td>1.3°F DB</td>
</tr>
</tbody>
</table>

**Water Side Performance**

<table>
<thead>
<tr>
<th>Field</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooling GPM / Fluid PD:</td>
<td>9 / 5.95 ft</td>
</tr>
<tr>
<td>Cooling Ent. / Lv. Fluid Temp:</td>
<td>90.00 / 98.11 °F</td>
</tr>
<tr>
<td>Heating GPM / Fluid PD:</td>
<td>9 / 4.86 ft</td>
</tr>
<tr>
<td>Heating Ent. / Lv. Fluid Temp:</td>
<td>35.00 / 29.95 °F</td>
</tr>
<tr>
<td>Fluid:</td>
<td>PropyleneGlycol - 35%</td>
</tr>
</tbody>
</table>

**Max Operating Pressure**: 300 psig

**Rating Information**

- Cooling Capacity (MBH): 36.1
- Cooling EER: 15.2
- Heating High Temp Capacity (MBH): 43.5
- Heating High Temp COP: 5

**Application EER @ Op. Conditions**: 9.5

**Application COPH @ Op. Conditions**: 3.47

**Electrical Data**

<table>
<thead>
<tr>
<th>Field</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rating:</td>
<td>460/3/60</td>
</tr>
<tr>
<td>Unit FLA:</td>
<td>7</td>
</tr>
<tr>
<td>Minimum Circuit Amp:</td>
<td>8</td>
</tr>
<tr>
<td>Maximum Overcurrent:</td>
<td>15</td>
</tr>
<tr>
<td>Qty</td>
<td>HP</td>
</tr>
<tr>
<td>Compressor 1:</td>
<td>1</td>
</tr>
<tr>
<td>Supply Fan:</td>
<td>1</td>
</tr>
</tbody>
</table>

(**) Fan motor temperature rise is not included in the heat capacity and temps.
**Tag:** HHP-004

*(Values do not account for changes described in SPA)*

### Job Information

- **Job Name:** NAIC
- **Job Number:** Job #184
- **Site Altitude:** 4793

### Static Pressure

- **Max Avail. External:** 0.18/0.73/1.28 (Low/Med/High)
- **Evaporator:** 0.16 in. wg
- **Filters Clean:**
- **Dirt Allowance:**

### Cooling Section

<table>
<thead>
<tr>
<th>Gross</th>
<th>Net</th>
</tr>
</thead>
<tbody>
<tr>
<td>41.44</td>
<td>38.89 MBH</td>
</tr>
<tr>
<td>41.44</td>
<td>38.89 MBH</td>
</tr>
<tr>
<td>0.00 MBH</td>
<td></td>
</tr>
<tr>
<td>75.00 °F DB</td>
<td>56.00 °F WB</td>
</tr>
<tr>
<td>75.00 °F DB</td>
<td>56.00 °F WB</td>
</tr>
<tr>
<td>46.12 °F DB</td>
<td>46.11 °F WB</td>
</tr>
<tr>
<td>47.92 °F DB</td>
<td>46.88 °F WB</td>
</tr>
<tr>
<td>1 x 1108R34EC @ 0.80 BHP Ea.</td>
<td></td>
</tr>
<tr>
<td>790/995/1176 rpm (Low/Med/High)</td>
<td></td>
</tr>
<tr>
<td>5.7 ft²</td>
<td></td>
</tr>
<tr>
<td>278.6 fpm / 1600 CFM</td>
<td></td>
</tr>
</tbody>
</table>

### Heating Section(**)

- **Primary Heat Type:** Heat Pump
- **Total Capacity:** 45.3 MBH
- **RA Temp:** 70.0°F DB / 62.00°F WB
- **Entering Air Temp:** 70.0°F DB / 62.00°F WB
- **Leaving Air Temp:** 101.2°F DB / 70.80°F WB
- **Auxiliary Heat Type:** None
- **Heating CFM:** 1600
- **Fan Temp Rise:** 1.8°F DB

### Water Side Performance:

- **Cooling GPM / Fluid PD:** 12 / 4.46 ft
- **Cooling Ent. / Lv. Fluid Temp:** 90.00 / 98.54 °F
- **Heating GPM / Fluid PD:** 12 / 4.35 ft
- **Heating Ent. / Lv. Fluid Temp:** 35.00 / 29.37 °F
- **Fluid:** PropyleneGlycol - 35%
- **Max Operating Pressure:** 300 psig

### Rating Information

- **Cooling Capacity (MBH):** 51.7
- **Cooling EER:** 16.8
- **Heating High Temp Capacity (MBH):** 63.2
- **Heating High Temp COP:** 5.3

### Rated in accordance with ISO 13256-1

- **Application EER @ Op. Conditions:** 9.7
- **Application COPH @ Op. Conditions:** 3.73

### Electrical Data

<table>
<thead>
<tr>
<th>Rating</th>
<th>460/3/60</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Qty</th>
<th>HP</th>
<th>VAC</th>
<th>Phase</th>
<th>RPM</th>
<th>FLA</th>
<th>RLA</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.75</td>
<td>460</td>
<td>3</td>
<td>3500</td>
<td>6.2</td>
<td>2.1</td>
</tr>
</tbody>
</table>

(**)Fan motor temperature rise is not included in the heat capacity and temps.
Tag: HHP-005

(Values do not account for changes described in SPA)

**Job Information**

- **Job Name:** NAIC
- **Job Number:** Job #184
- **Site Altitude:** 4733

**Static Pressure**

- **Max Avail. External:** NA/0.27/0.57 (Low/Med/High)
- **Evaporator:** 0.23 in. wg
- **Filters Clean:**
- **Dirt Allowance:**

**Cooling Section**

- **Total Capacity:**
  - Gross: 50.44 MBH
  - Net: 47.59 MBH
- **Sensible Capacity:** 50.44 MBH
- **Latent Capacity:** 0.00 MBH
- **Mixed Air Temp:** 75.00 °F DB / 56.00 °F WB
- **Entering Air Temp:** 75.00 °F DB / 56.00 °F WB
- **Lv Air Temp (Coil):** 46.88 °F DB / 46.87 °F WB
- **Lv Air Temp (Unit):** 48.49 °F DB / 47.55 °F WB
- **Supply Air Fan:** 1 x 1108R34EC @ 0.90 BHP Ea.
- **SA Fan RPM:** NA/976/1089 rpm (Low/Med/High)
- **Evaporator Coil:** 5.7 ft²
- **Evaporator Face Velocity:** 348.2 fpm / 2000 CFM

**Heating Section(***)**

- Primary Heat Type: Heat Pump
- Total Capacity: 56.2 MBH
- RA Temp: 70.0°F DB / 62.00°F WB
- Entering Air Temp: 70.0°F DB / 62.00°F WB
- Leaving Air Temp: 101.0°F DB / 70.74°F WB
- Auxiliary Heat Type: None
- Heating CFM: 2000
- Fan Temp Rise: 1.6°F DB

**Water Side Performance:**

- Cooling GPM / Fluid PD: 15 / 6.21 ft
- Heating GPM / Fluid PD: 15 / 5.05 ft
- Heating Ent. / Lv. Fluid Temp: 35.00 / 29.39 °F
- Fluid: PropyleneGlycol - 35%
- Max Operating Pressure: 300 psig

**Rating Information**

- **Cooling Capacity (MBH):** 61.0
- **Cooling EER:** 15.1
- **Heating High Temp Capacity (MBH):** 76.7
- **Heating High Temp COP:** 4.8

*Rated in accordance with ISO 13256-1*

**Application EER @ Op. Conditions:** 9.7
**Application COPh @ Op. Conditions:** 3.87

**Electrical Data**

- **Rating:** 460/3/60
- **Unit FLA:** 10
- **Minimum Circuit Amp:** 12
- **Maximum Overcurrent:** 15

<table>
<thead>
<tr>
<th>Quantity</th>
<th>HP</th>
<th>VAC</th>
<th>Phase</th>
<th>RPM</th>
<th>FLA</th>
<th>RLA</th>
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</thead>
<tbody>
<tr>
<td><strong>Compressor 1:</strong></td>
<td>1</td>
<td>460</td>
<td>3</td>
<td>3500</td>
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<td><strong>Supply Fan:</strong></td>
<td>1</td>
<td>0.75</td>
<td>460</td>
<td>1</td>
<td>1200</td>
<td>2.1</td>
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</table>

(***)Fan motor temperature rise is not included in the heat capacity and temps.
AAON RIGHT HANDED HORIZONTAL WATER-SOURCE HEAT PUMP 2-2 1/2 TON

<table>
<thead>
<tr>
<th>2-2 1/2</th>
<th>TYPE/SIZE</th>
</tr>
</thead>
<tbody>
<tr>
<td>WATER IN</td>
<td>3/4&quot; FEMALE PIPE THREAD</td>
</tr>
<tr>
<td>WATER OUT</td>
<td>3/4&quot; FEMALE PIPE THREAD</td>
</tr>
<tr>
<td>CONDENSATE</td>
<td>7/8&quot; HOSE CONNECTION</td>
</tr>
<tr>
<td>FILTERS</td>
<td>(2) 16&quot;X16&quot;X2&quot;</td>
</tr>
</tbody>
</table>

ALL DIMENSIONS ARE IN INCHES
TOLERANCE IS +/- 1/4
AAON RIGHT HANDED
HORIZONTAL WATER-SOURCE
HEAT PUMP 2-2 1/2 TON

<table>
<thead>
<tr>
<th>2-2 1/2</th>
<th>TYPE/SIZE</th>
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<tbody>
<tr>
<td>WATER IN</td>
<td>3/4&quot; FEMALE PIPE THREAD</td>
</tr>
<tr>
<td>WATER OUT</td>
<td>3/4&quot; FEMALE PIPE THREAD</td>
</tr>
<tr>
<td>CONDENSATE</td>
<td>7/8&quot; HOSE CONNECTION</td>
</tr>
<tr>
<td>FILTERS</td>
<td>(2) 16&quot;X16&quot;X2&quot;</td>
</tr>
</tbody>
</table>

REV. A 01/15/16 AAS
ALL DIMENSIONS ARE IN INCHES
TOLERANCE IS +/- 1/4
# AAON RIGHT HANDED HORIZONTAL WATER-SOURCE HEAT PUMP 3-3 1/2 TON

<table>
<thead>
<tr>
<th>3-3 1/2</th>
<th>TYPE/SIZE</th>
</tr>
</thead>
<tbody>
<tr>
<td>WATER IN</td>
<td>3/4&quot; FEMALE PIPE THREAD</td>
</tr>
<tr>
<td>WATER OUT</td>
<td>3/4&quot; FEMALE PIPE THREAD</td>
</tr>
<tr>
<td>CONDENSATE</td>
<td>7/8&quot; HOSE CONNECTION</td>
</tr>
<tr>
<td>FILTERS</td>
<td>(2) 20&quot;X20&quot;X2&quot;</td>
</tr>
</tbody>
</table>

---

**TOP VIEW**

**INTAKE VIEW**

---

REV. A 01/15/16 AAS

*ALL DIMENSIONS ARE IN INCHES*  
*TOLERANCE IS +/- 1/4*
AAON RIGHT HANDED
HORIZONTAL WATER-SOURCE
HEAT PUMP 3-3 1/2 TON

3-3 1/2

<table>
<thead>
<tr>
<th>TYPE/SIZE</th>
</tr>
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<tbody>
<tr>
<td>WATER IN</td>
</tr>
<tr>
<td>3/4 &quot; FEMALE PIPE THREAD</td>
</tr>
<tr>
<td>WATER OUT</td>
</tr>
<tr>
<td>3/4&quot; FEMALE PIPE THREAD</td>
</tr>
<tr>
<td>CONDENSATE</td>
</tr>
<tr>
<td>7/8&quot; HOSE CONNECTION</td>
</tr>
<tr>
<td>FILTERS</td>
</tr>
<tr>
<td>(2) 20&quot;X20&quot;X2&quot;</td>
</tr>
</tbody>
</table>

BACK VIEW
(FIELD ADJUSTED DISCHARGE)

DISCHARGE VIEW

FRONT VIEW

BACK VIEW

CONTROLS SERVICE ACCESS PANEL

WATER IN
3/4" FEMALE PIPE THREAD

WATER OUT
3/4" FEMALE PIPE THREAD

CONDENSATE
7/8" HOSE CONNECTION

FILTERS
(2) 20"X20"X2"

WATER IN

WATER OUT

CONDENSATE
7/8" HOSE CONNECTION

(2) 20"X20"X2"

REV. A 01/15/16 AAS

ALL DIMENSIONS ARE IN INCHES
TOLERANCE IS +/- 1/4
AAON WH-SERIES RIGHT HANDED
HORIZONTAL WATER-SOURCE HEAT PUMP
E-CABINET

<table>
<thead>
<tr>
<th>E-CABINET</th>
<th>TYPE</th>
<th>4 TON</th>
<th>5 TON</th>
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<tbody>
<tr>
<td>WATER IN</td>
<td>FEMALE PIPE THREAD</td>
<td>3/4&quot;</td>
<td>1&quot;</td>
</tr>
<tr>
<td>WATER OUT</td>
<td>FEMALE PIPE THREAD</td>
<td>3/4&quot;</td>
<td>1&quot;</td>
</tr>
<tr>
<td>CONDENSATE</td>
<td>HOSE CONNECTION</td>
<td>7/8&quot;</td>
<td>7/8&quot;</td>
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</table>

**DIMENSIONS**

<table>
<thead>
<tr>
<th>SIZE</th>
<th>A</th>
<th>B</th>
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</thead>
<tbody>
<tr>
<td>Filters</td>
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<td></td>
</tr>
<tr>
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<td>2 1/2&quot;</td>
<td>27 5/8&quot;</td>
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<td>16&quot;x20&quot;x4&quot;</td>
<td>4 1/2&quot;</td>
<td>29 5/8&quot;</td>
</tr>
</tbody>
</table>

**CLEARANCES**

NOTE DIMENSIONS IN ISOMETRIC VIEWS FOR CLEARANCE.
* IF BOTTOM ACCESS IS NOT AVAILABLE, OPTIONAL DIMENSIONS BECOME REQUIRED.

**TOP VIEW**

**INTAKE VIEW**

WHE-00009A  REV. A  03/24/16  AAS
ALL DIMENSIONS ARE IN INCHES
TOLERANCE IS +/- 1/4
AAON WH-SERIES RIGHT HANDED
HORIZONTAL WATER-SOURCE HEAT PUMP
E-CABINET

E-CABINET | TYPE | 4 TON | 5 TON
---|---|---|---
WATER IN | FEMALE PIPE THREAD | 3/4" | 1"
WATER OUT | FEMALE PIPE THREAD | 3/4" | 1"
CONDENSATE | HOSE CONNECTION | 7/8" | 7/8"

<table>
<thead>
<tr>
<th>SIZE</th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>FILTERS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16&quot;x20&quot;x2&quot;</td>
<td>2 1/2&quot;</td>
<td>27 5/8&quot;</td>
</tr>
<tr>
<td>16&quot;x20&quot;x4&quot;</td>
<td>4 1/2&quot;</td>
<td>29 5/8&quot;</td>
</tr>
</tbody>
</table>

CLEARANCES
NOTE DIMENSIONS IN ISOMETRIC VIEWS FOR CLEARANCE.
* IF BOTTOM ACCESS IS NOT AVAILABLE, OPTIONAL DIMENSIONS BECOME REQUIRED.

WHE-00009B REV. A 03/24/16 AAS
ALL DIMENSIONS ARE IN INCHES
TOLERANCE IS +/- 1/4
Subject: FW: NAIC WH Heat Pumps
From: BruceC@vemcoinc.com
Sent: 10/17/2016 1:35:55 PM
To: toddm@acemt.com
CC: aarons@acemt.com; danf@vemcoinc.com

Todd and Aaron,

Below is the project specific performance data and electrical data on the 1-ton and ½-ton AAON horizontal heat pumps. Give me a call if you have any questions.

Thanks

Bruce Cook
Vemco Inc.
406-281-7558 - Direct

---

From: Alex Foster [mailto:alexf@aaon.com]
Sent: Monday, October 17, 2016 1:26 PM
To: Bruce Cook
Cc: Dan Fry
Subject: RE: NAIC WH Heat Pumps

Bruce,

See below for electrical rating of the units:

<table>
<thead>
<tr>
<th></th>
<th>MCA</th>
<th>MOP</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5 ton</td>
<td>4.5</td>
<td>15</td>
</tr>
<tr>
<td>1 ton</td>
<td>8</td>
<td>15</td>
</tr>
</tbody>
</table>

See below for performance numbers at the conditions listed:

<table>
<thead>
<tr>
<th></th>
<th>Cooling</th>
<th>Heating</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Capacity</td>
<td>EER</td>
</tr>
<tr>
<td>0.5 ton</td>
<td>4924</td>
<td>9.2</td>
</tr>
<tr>
<td>1 ton</td>
<td>11660</td>
<td>11.3</td>
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</table>

Let me know if you need anything else.

Thank you,

Alex Foster
Good Morning Alex,

As we discussed, we are trying to fill in the holes on the horizontal heat pumps for the NAIC project at Montana State University. Tomorrow is their deadline for publishing 100% documents. We are in need of performance data on the 1-ton and ½-ton units. Also need electrical data at 265/1/60. Site conditions as follows.

EC motors
75°/56° cooling entering air temp – 90° entering fluid – 35% propylene glycol
70° heating entering air temp – 35° entering fluid – 35% propylene glycol

1-ton unit: 400 CFM / 3.0 gpm
½-ton unit: 250 CFM / 1.5 gpm

Give me a call if you have any questions.
Thanks for your help.

Bruce Cook
Vemco Inc.
406-281-7558 - Direct
AAON WH-SERIES RIGHT HANDED HORIZONTAL WATER-SOURCE HEAT PUMP A-CABINET

<table>
<thead>
<tr>
<th>A-CABINET</th>
<th>TYPE</th>
<th>1/2, 3/4, &amp; 1 TON</th>
</tr>
</thead>
<tbody>
<tr>
<td>WATER IN</td>
<td>FEMALE PIPE THREAD</td>
<td>1/2&quot;</td>
</tr>
<tr>
<td>WATER OUT</td>
<td>FEMALE PIPE THREAD</td>
<td>1/2&quot;</td>
</tr>
<tr>
<td>CONDENSATE</td>
<td>HOSE CONNECTION</td>
<td>7/8&quot;</td>
</tr>
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</table>

**DIMENSIONS**

<table>
<thead>
<tr>
<th>SIZE</th>
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<th>B</th>
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<tr>
<td>16&quot;X16&quot;X2&quot;</td>
<td>2&quot;</td>
<td>23 1/4&quot;</td>
</tr>
<tr>
<td>16&quot;X16&quot;X4&quot;</td>
<td>4&quot;</td>
<td>25 1/4&quot;</td>
</tr>
</tbody>
</table>

**CLEARANCES**

NOTE DIMENSIONS IN ISOMETRIC VIEWS FOR CLEARANCE.

* IF BOTTOM ACCESS IS NOT AVAILABLE, OPTIONAL DIMENSIONS BECOME REQUIRED.
AAON WH-SERIES RIGHT HANDED
HORIZONTAL WATER-SOURCE HEAT PUMP
A-CABINET

A-CABINET | TYPE | 1/2, 3/4, & 1 TON
---|---|---
WATER IN | FEMALE PIPE THREAD | 1/2"
WATER OUT | FEMALE PIPE THREAD | 1/2"
CONDENSATE | HOSE CONNECTION | 7/8"

<table>
<thead>
<tr>
<th>FILTERS</th>
<th>SIZE</th>
<th>DIMENSIONS</th>
</tr>
</thead>
</table>
| 16"X16"X2" | 2" | 23 1/4"
| 16"X16"X4" | 4" | 25 1/4"

CLEARANCES
NOTE DIMENSIONS IN ISOMETRIC VIEWS FOR CLEARANCE.
* IF BOTTOM ACCESS IS NOT AVAILABLE, OPTIONAL DIMENSIONS BECOME REQUIRED.

CONTROL SERVICE ACCESS PANEL

FAN SERVICE ACCESS PANEL

CONDENSATE HOSE CONNECTION

20" STRAIGHT DISCHARGE

END DISCHARGE (OPTIONAL)

AIR INTAKE (FILTERS)

WHA-00017B REV. A 06/09/16 AAS
ALL DIMENSIONS ARE IN INCHES
TOLERANCE IS +/- 1/4

PAGE 2 OF 2
**Job Information**

- **Job Name:** NAIC
- **Job Number:** Job #184
- **Site Altitude:** 4793 ft
- **Refrigerant:** R-410A

**Static Pressure**

- **External:** 0.60 in. wg.
- **Evaporator:** 0.23 in. wg.
- **Filters Clean:** 0.07 in. wg.
- **Dirt Allowance:** 0.35 in. wg.

**Cooling Section**

- **Total Capacity:** Gross 33.33 MBH
- **Sensible Capacity:** 32.92 MBH
- **Latent Capacity:** 0.41 MBH
- **Mixed Air Temp:** 75.00 °F DB
- **Entering Air Temp:** 75.00 °F DB
- **Lv Air Temp (Coil):** 44.42 °F DB
- **Lv Air Temp (Unit):** 45.61 °F DB
- **Supply Air Fan:** 1 x 250AY @ 0.44 BHP
- **SA Fan RPM / Width:** 2925 / 3.150"
- **Evaporator Coil:** 3.7 ft² / 4 Rows / 12 FPI
- **Evaporator Face Velocity:** 327.3 fpm

**Unit Information**

- **Approx. Op./Ship Weights:** 703 / 703 lbs. (±5%)
- **Supply CFM/ESP:** 1200 / 0.6 in. wg.
- **Outside CFM:** 360
- **Ambient Temperature:** 95 °F DB / 63 °F WB
- **Return Temperature:** 75 °F DB / 56 °F WB

**Heating Section**

- **Primary Heat Type:** Heat Pump
- **Total Capacity:** 35.0 MBH
- **RA Temp:** 70.0 °F DB / 56.0 °F WB
- **Entering Air Temp:** 70.0 DB / 56.0 °F WB
- **Leaving Air Temp:** 102.3 DB / 66.2°F WB
- **Auxiliary Heat Type:** No Heat
- **Heating CFM:** 1200
- **Fan Temp Rise:** 1.2 °F

**Water Side Performance**

- **Cooling GPM / Gly. PD:** 9 / 6.26 ft
- **Cooling Ent. / Lv. Gly. Temp:** 90 / 100.2 °F
- **Heating GPM / Gly. PD:** 9 / 6.26 ft
- **Heating Ent. / Lv. Gly. Temp:** 35 / 28.97 °F
- **Glycol %:** 35

**AHRI Listing Information**

**Application EER @ Op. Conditions:** 10.7

**Application COP** @ Op. Conditions: 3.14

**Electrical Data**

- **Rating:** 460/3/60
- **Unit FLA:** 8
- **Min. Circuit Amp:** 9
- **Max. Overcurrent:** 15

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<th>Qty</th>
<th>HP</th>
<th>VAC</th>
<th>Phase</th>
<th>RPM</th>
<th>FLA</th>
<th>RLA</th>
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<td>1.10</td>
<td>460</td>
<td>3</td>
<td>3450</td>
<td>6.2</td>
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</table>

**Cabinet Sound Power Levels**

- **Octave Bands:** 63 125 250 500 1000 2000 4000 8000
- **Discharge LW(dB):** 74 67 72 75 77 76 71 69
- **Return LW(dB):** 71 62 68 70 67 63 59 58

*Sound power levels are given for informational purposes only. The sound levels are not guaranteed.

(**) Fan motor temperature rise is not included in the heat capacity and temps.
Tag: SB-004

**Job Information**

- **Job Name:** NAIC
- **Job Number:** Job #184
- **Site Altitude:** 4793 ft
- **Refrigerant:** R-410A

**Static Pressure**

- **External:** 0.60 in. wg.
- **Evaporator:** 0.37 in. wg.
- **Filters Clean:** 0.32 in. wg.
- **Dirt Allowance:** 0.35 in. wg.

**Cooling Section**

- **Total Capacity:**
  - Gross: 40.36 MBH
  - Net: 38.15 MBH
- **Sensible Capacity:**
  - Gross: 40.36 MBH
  - Net: 38.15 MBH
- **Latent Capacity:**
  - 0.00 MBH
- **Mixed Air Temp:** 75.00 °F DB / 56.00 °F WB
- **Entering Air Temp:** 75.00 °F DB / 56.00 °F WB
- **Lv Air Temp (Coil):**
  - 46.88 °F DB / 44.93 °F WB
- **Lv Air Temp (Unit):**
  - 48.39 °F DB / 45.99 °F WB

- **Digital Comp. Capacity Ratio:** 100%
- **Supply Air Fan:** 1 x 310AX @ 0.76 BHP
- **SA Fan RPM / Width:** 2249 / 5.790"
- **Evaporator Coil:**
  - 3.7 ft² / 4 Rows / 12 FPI
- **Evaporator Face Velocity:** 436.4 fpm

**AHRI Listing Information**

**Application EER @ Op. Conditions:** 10.5

**Application COPH @ Op. Conditions:** 3.08

**Electrical Data**

- **Rating:** 460/3/60
- **Unit FLA:** 10

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<thead>
<tr>
<th>qty</th>
<th>HP</th>
<th>VAC</th>
<th>Phase</th>
<th>RPM</th>
<th>FLA</th>
<th>RLA</th>
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</thead>
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<td>1</td>
<td>1.34</td>
<td>460</td>
<td>3</td>
<td>2580</td>
<td>1.7</td>
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</table>

**Cabinet Sound Power Levels**

- Octave Bands: 63 125 250 500 1000 2000 4000 8000
- Discharge LW(dB): 67 66 72 73 75 74 71 70
- Return LW(dB): 57 61 69 66 62 61 57 55

*Sound power levels are given for informational purposes only. The sound levels are not guaranteed.

(**) Fan motor temperature rise is not included in the heat capacity and temps.
### Job Information

<table>
<thead>
<tr>
<th>Job Name:</th>
<th>NAIC</th>
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</thead>
<tbody>
<tr>
<td>Job Number:</td>
<td>Job #184</td>
</tr>
<tr>
<td>Site Altitude:</td>
<td>4793 ft</td>
</tr>
<tr>
<td>Refrigerant:</td>
<td>R-410A</td>
</tr>
</tbody>
</table>

### Static Pressure

| External: | 0.60 in. wg. |
| Evaporator: | 0.58 in. wg. |
| Filters Clean: | 0.20 in. wg. |
| Dirt Allowance: | 0.35 in. wg. |

### Cooling Section

| Gross | 50.86 |
| Net | 47.80 MBH |
| Sensible Capacity: | 50.86 |
| Latent Capacity: | 0.00 MBH |
| Mixed Air Temp: | 75.00 °F DB / 56.00 °F WB |
| Entering Air Temp: | 75.00 °F DB / 56.00 °F WB |
| Lvr Air Temp (Coil): | 46.65 °F DB / 44.83 °F WB |
| Lvr Air Temp (Unit): | 48.33 °F DB / 45.56 °F WB |
| Digital Comp. Capacity Ratio: | 100% |
| Supply Air Fan: | 1 x 355AY @ 1.03 BHP |
| SA Fan RPM / Width: | 2082 / 6.460 |
| Evaporator Coil: | 3.7 ft² / 4 Rows / 12 FPI |
| Evaporator Face Velocity: | 545.5 fpm |

### Heating Section(**)

| Primary Heat Type: | Heat Pump |
| Total Capacity: | 52.6 MBH |
| RA Temp: | 70.0 °F DB / 60.0 °F WB |
| Entering Air Temp: | 70.0 DB / 60.0 °F WB |
| Leaving Air Temp: | 99.1 DB / 68.6°F WB |
| Auxiliary Heat Type: | No Heat |
| Heating CFM: | 2000 |
| Fan Temp Rise: | 1.7 °F |

### Water Side Performance:

| Cooling GPM / Gly. PD: | 15 / 9.78 ft |
| Cooling Ent. / Lv. Gly. Temp: | 90 / 99.2 °F |
| Heating GPM / Gly. PD: | 15 / 9.78 ft |
| Heating Ent. / Lv. Gly. Temp: | 35 / 29.66 °F |
| Glycol %: | 35 |

### AHRI Listing Information

#### Application EER @ Op. Conditions:

- **10.3**

#### Application COP<sub>h</sub> @ Op. Conditions:

- **3**

### Electrical Data

| Rating: | 460/3/60 |
| Unit FLA: | 11 |
| Qty | HP | VAC | Phase | RPM | FLA | RLA |
| Compressor 1: | 1 | 460 | 3 | 2.6 |
| Supply Fan: | 1 | 2.30 | 460 | 3 | 2600 | 8.1 |

### Cabinet Sound Power Levels*

| Octave Bands: | 63 | 125 | 250 | 500 | 1000 | 2000 | 4000 | 8000 |
| Discharge LW(dB): | 68 | 72 | 77 | 78 | 79 | 77 | 75 | 72 |
| Return LW(dB): | 58 | 62 | 70 | 67 | 64 | 63 | 59 | 57 |

*Sound power levels are given for informational purposes only. The sound levels are not guaranteed. **Fan motor temperature rise is not included in the heat capacity and temps.**
**Job Information**

- **Job Name:** NAIC
- **Job Number:** Job #184
- **Site Altitude:** 4793 ft
- **Refrigerant:** R-410A

**Static Pressure**

- **External:** 0.60 in. wg.
- **Evaporator:** 0.25 in. wg.
- **Filters Clean:** 0.06 in. wg.
- **Dirt Allowance:** 0.35 in. wg.

**Cooling Section**

- **Total Capacity:** Gross 68.14 MBH, Net 65.98 MBH
- **Sensible Capacity:** 66.34 MBH
- **Latent Capacity:** 1.80 MBH
- **Mixed Air Temp:** 75.00 °F DB, 56.00 °F WB
- **Entering Air Temp:** 75.00 °F DB, 56.00 °F WB
- **LV Air Temp (Coil):** 44.18 °F DB, 43.44 °F WB
- **LV Air Temp (Unit):** 45.17 °F DB, 43.88 °F WB
- **Digital Comp. Capacity Ratio:** 100%
- **Supply Air Fan:** 1 x 450AZ @ 0.77 BHP
- **SA Fan RPM / Width:** 1385 / 8.030”
- **Evaporator Coil:** 7.1 ft² / 4 Rows / 12 FPI
- **Evaporator Face Velocity:** 337.5 fpm

**AHRI Listing Information**

**Application EER @ Op. Conditions:** 11.2

**Electrical Data**

- **Rating:** 460/3/60
- **Unit FLA:** 20
- **Compressor 1:** Qty 1, HP 460, VAC 3, RPM 2750, FLA 11.2, RLA 8.3
- **Supply Fan:** Qty 1, HP 8.00, VAC 3, RPM 2750, FLA 11.2, RLA 8.3

**Cabinet Sound Power Levels**

- **Octave Bands:** 63 / 125 / 250 / 500 / 1000 / 2000 / 4000 / 8000
  - **Discharge LW(dB):** 71 / 75 / 74 / 78 / 73 / 69 / 65 / 60
  - **Return LW(dB):** 67 / 71 / 66 / 64 / 64 / 59 / 55 / 50

*Sound power levels are given for informational purposes only. The sound levels are not guaranteed.

**Unit Information**

- **Approx. Op./Ship Weights:** 815 / 815 lbs. (±5%)  
- **Supply CFM/ESP:** 2400 / 0.6 in. wg.  
- **Outside CFM:** 360  
- **Ambient Temperature:** 95 °F DB / 63 °F WB  
- **Return Temperature:** 75 °F DB / 56 °F WB  
- **Economizer:** 0.00 in. wg.  
- **Heating:** 0.00 in. wg.  
- **Cabinet:** 0.02 in. wg.  
- **Total:** 1.26 in. wg.

**Heating Section(**)**

- **Primary Heat Type:** Heat Pump  
- **Total Capacity:** 70.7 MBH  
- **RA Temp:** 70.0 °F DB / 60.0 °F WB  
- **Entering Air Temp:** 70.0 DB / 60.0 °F WB  
- **Leaving Air Temp:** 102.6 DB / 69.5°F WB  
- **Auxiliary Heat Type:** No Heat  
- **Heating CFM:** 2400  
- **Fan Temp Rise:** 1.0 °F

**Water Side Performance**

- **Cooling GPM / Gly. PD:** 18 / 6.26 ft
- **Cooling Ent. / Lv. Gly. Temp:** 90 / 100.4 °F
- **Heating GPM / Gly. PD:** 18 / 6.26 ft
- **Heating Ent. / Lv. Gly. Temp:** 35 / 28.76 °F
- **Glycol %:** 35

**AHRI Listing Information**

**Application COP_H @ Op. Conditions:** 3.27
### Job Information

<table>
<thead>
<tr>
<th>Field</th>
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<tbody>
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<td>Job Name</td>
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<tr>
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<td>Job #184</td>
</tr>
<tr>
<td>Site Altitude</td>
<td>4793 ft</td>
</tr>
<tr>
<td>Refrigerant</td>
<td>R-410A</td>
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</table>

### Static Pressure

<table>
<thead>
<tr>
<th>Field</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>External</td>
<td>0.60 in. wg.</td>
</tr>
<tr>
<td>Evaporator</td>
<td>0.33 in. wg.</td>
</tr>
<tr>
<td>Filters Clean</td>
<td>0.08 in. wg.</td>
</tr>
<tr>
<td>Dirt Allowance</td>
<td>0.35 in. wg.</td>
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</tbody>
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### Cooling Section

<table>
<thead>
<tr>
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<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Total Capacity: Gross</td>
<td>78.99 MBH</td>
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<tr>
<td>Total Capacity: Net</td>
<td>76.26 MBH</td>
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<tr>
<td>Sensible Capacity: Gross</td>
<td>76.90 MBH</td>
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<tr>
<td>Sensible Capacity: Net</td>
<td>74.17 MBH</td>
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<tr>
<td>Latent Capacity:</td>
<td>2.09 MBH</td>
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<tr>
<td>Mixed Air Temp:</td>
<td>75.00 °F DB / 56.00 °F WB</td>
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<tr>
<td>Entering Air Temp:</td>
<td>75.00 °F DB / 56.00 °F WB</td>
</tr>
<tr>
<td>Lv Air Temp (Coil):</td>
<td>44.38 °F DB / 43.44 °F WB</td>
</tr>
<tr>
<td>Lv Air Temp (Unit):</td>
<td>45.44 °F DB / 43.92 °F WB</td>
</tr>
<tr>
<td>Digital Comp. Capacity Ratio:</td>
<td>100%</td>
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<tr>
<td>Supply Air Fan:</td>
<td>1 x 450AZ @ 0.97 BHP</td>
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<tr>
<td>SA Fan RPM / Width:</td>
<td>1503 / 8.030&quot;</td>
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<tr>
<td>Evaporator Coil:</td>
<td>7.1 ft² / 4 Rows / 12 FPI</td>
</tr>
<tr>
<td>Evaporator Face Velocity:</td>
<td>393.8 fpm</td>
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### Heating Section

<table>
<thead>
<tr>
<th>Field</th>
<th>Value</th>
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<tbody>
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<td>Primary Heat Type:</td>
<td>Heat Pump</td>
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<tr>
<td>Total Capacity:</td>
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<tr>
<td>RA Temp:</td>
<td>70.0 °F DB / 60.0 °F WB</td>
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<tr>
<td>Entering Air Temp:</td>
<td>70.0 DB / 60.0 °F WB</td>
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<tr>
<td>Leaving Air Temp:</td>
<td>102.9 DB / 69.6°F WB</td>
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<tr>
<td>Auxiliary Heat Type:</td>
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<td>Heating CFM:</td>
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<td>Fan Temp Rise:</td>
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### Water Side Performance

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<tr>
<td>Heating GPM / Gly. PD</td>
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<td>Heating Ent. / Lv. Gly. Temp:</td>
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<tr>
<td>Glycol %</td>
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### AHRI Listing Information

<table>
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<td>Application COP&lt;sub&gt;H&lt;/sub&gt; @ Op. Conditions:</td>
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### Electrical Data

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<td>Unit FLA:</td>
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<td>Minimum Circuit Amp:</td>
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<tr>
<td>Compressor 1:</td>
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<tr>
<td>Supply Fan:</td>
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<table>
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### Cabinet Sound Power Levels

<table>
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<th>Value</th>
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<td>Octave Bands:</td>
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<td>Discharge LW(dB):</td>
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<table>
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<td>4000</td>
<td>8000</td>
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</tbody>
</table>

*Sound power levels are given for informational purposes only. The sound levels are not guaranteed.

(**) Fan motor temperature rise is not included in the heat capacity and temps.
Job Information

Job Name: NAIC
Job Number: Job #184
Site Altitude: 4793 ft
Refrigerant: R-410A

Static Pressure

External: 0.60 in. wg.
Evaporator: 0.59 in. wg.
Filters Clean: 0.16 in. wg.
Dirt Allowance: 0.35 in. wg.

Cooling Section

Total Capacity: Gross 96.72 MBH
Sensible Capacity: Gross 96.72 MBH
Latent Capacity: 0.00 MBH
Mixed Air Temp: 75.00 °F DB / 56.00 °F WB
Entering Air Temp: 75.00 °F DB / 56.00 °F WB
Lv Air Temp (Coil): 48.05 °F DB / 45.44 °F WB
Lv Air Temp (Unit): 49.48 °F DB / 46.06 °F WB
Digital Comp. Capacity Ratio: 100%
Supply Air Fan: Multi 450AZ @ 1.87 BHP
SA Fan RPM / Width: 1913 / 8.030"
Evaporator Coil: 7.1 ft² / 4 Rows / 12 FPI
Evaporator Face Velocity: 562.5 fpm

AHRI Listing Information

AHRI Listing Information

Application EER @ Op. Conditions: 10.5
Application COP@ Op. Conditions: 3.07

Electrical Data

Rating: 460/3/60
Unit FLA: 25

<table>
<thead>
<tr>
<th>Qty</th>
<th>HP</th>
<th>VAC</th>
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<tbody>
<tr>
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<td>8.00</td>
<td>460</td>
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Compressor 1:

Supply Fan:

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<th>Qty</th>
<th>HP</th>
<th>VAC</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>8.00</td>
<td>460</td>
</tr>
</tbody>
</table>

Cabinet Sound Power Levels*

Octave Bands: 63 125 250
Discharge LW(dB): 73 76 82
Return LW(dB): 68 72 78

*Sound power levels are given for informational purposes only. The sound levels are not guaranteed.

(**) Fan motor temperature rise is not included in the heat capacity and temps.
SECTION 23 82 36 - FINNED-TUBE RADIATION HEATERS

PART 1 - GENERAL

1.1 SUMMARY
   A. Section includes hydronic, finned-tube radiation heaters.

1.2 ACTION SUBMITTALS
   A. Product Data: For each type of product.
      1. Include rated capacities, operating characteristics, furnished specialties, and accessories.
   B. Shop Drawings:
      1. Include plans, elevations, sections, and 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 details and dimensions of custom-fabricated enclosures.
      4. Indicate location and size of each field connection.
      5. Indicate location and arrangement of piping valves and specialties.
      6. Indicate location and arrangement of integral controls.
      7. Include enclosure joints, corner pieces, access doors, and other accessories.
      8. Include diagrams for power, signal, and control wiring.
   C. Samples: For each exposed product and for each color and texture specified.

1.3 INFORMATIONAL SUBMITTALS
   A. Field quality-control reports.

PART 2 - PRODUCTS

2.1 HOT-WATER FINNED-TUBE RADIATION HEATERS
   A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1. Embassy Industries, Inc.
      2. Engineered Air.
      3. Hydro-Air Components Inc.
      4. Quincy Hydronic Technology.
      5. Rosemex Products.
      6. Slant/Fin Corp.
      7. Sterling HVAC Products.
      8. Trane.
B. Performance Ratings: Rate finned-tube radiation heaters according to Hydronics Institute's "I=B=R Testing and Rating Standard for Finned-Tube (Commercial) Radiation."

C. Heating Elements: Copper tubing mechanically expanded into flanged collars of evenly spaced aluminum fins resting on element supports. One end of tube shall be belled.

1. Tube Diameter: See Schedule on Drawings.
2. Fin Size: See Schedule on Drawings.
3. Fin Spacing: See Schedule on Drawings.
4. Number of Tiers: See Schedule on Drawings.
7. Average Water Temperature: See Schedule on Drawings.

D. Element Supports: Ball-bearing cradle type to permit longitudinal movement on enclosure brackets.

E. Front Panel: by General Contractor.

F. Support Brackets: Locate at maximum 36-inch spacing to support front panel and element.

G. Enclosure Style: by General Contractor See architectural plans for details.

PART 3 - EXECUTION

3.1 FINNED-TUBE RADIATION HEATER INSTALLATION

A. Install units level and plumb.

B. Install access doors for access to valves.

C. Install valves within reach of access door provided in enclosure.

D. Install piping within pedestals for freestanding units.

3.2 CONNECTIONS

A. Piping installation requirements are specified in Section 23 21 13 "Hydronic Piping" and Section 23 21 16 "Hydronic Piping Specialties." Section 15179 "Hydronic Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect hot-water finned-tube radiation heaters and components to piping according to Section 23 21 13 "Hydronic Piping" and Section 23 21 16 "Hydronic Piping Specialties." Section 15179 "Hydronic Piping Specialties."

1. Install shutoff valves on inlet and outlet, and balancing valve on outlet.

C. Install control valves as required by Section 23 09 23.11 "Control Valves."

D. Install piping adjacent to finned-tube radiation heaters to allow service and maintenance.
E. Ground electric finned-tube radiation heaters according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."

F. Connect wiring according to Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

3.3 FIELD QUALITY CONTROL

A. Perform the following field 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 operation.
   3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Units will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

END OF SECTION 23 82 36
SECTION 23 82 39.13 - CABINET UNIT HEATERS

PART 1 - GENERAL

1.1 SUMMARY
A. Section includes cabinet unit heaters with centrifugal fans and hot-water coils.

1.2 ACTION SUBMITTALS
A. Product Data: For each type of product.
   1. Include rated capacities, operating characteristics, furnished specialties, and accessories.
B. LEED Submittals:
   1. Product Data for Prerequisite IEQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."
C. Shop Drawings:
   1. Include plans, elevations, sections, and 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 location and size of each field connection.
   4. Include details of anchorages and attachments to structure and to supported equipment.
   5. Include equipment schedules to indicate rated capacities, operating characteristics, furnished specialties, and accessories.
   6. Indicate location and arrangement of piping valves and specialties.
   7. Indicate location and arrangement of integral controls.
D. Samples: For each exposed product and for each color and texture specified.

1.3 INFORMATIONAL SUBMITTALS
A. Coordination Drawings: Floor plans, reflected ceiling plans, and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
   1. Suspended ceiling components.
   2. Structural members to which cabinet unit heaters will be attached.
   3. Method of attaching hangers to building structure.
   4. Size and location of initial access modules for acoustical tile.
   5. Items penetrating finished ceiling, including the following:
      a. Lighting fixtures.
      b. Air outlets and inlets.
c. Speakers.
d. Sprinklers.
e. Access panels.

6. Perimeter moldings for exposed or partially exposed cabinets.

B. Seismic Qualification Certificates: Submit certification that cabinet unit heaters, accessories, and components will withstand seismic forces defined in Section 23 05 48 "Vibration and Seismic Controls for HVAC."

C. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Airtherm.
2. Berko.
3. Carrier Corporation.
5. Dunham-Bush.
6. Engineered Air.
7. IEC.
8. INDEECO.
10. Marley Engineered Products.
11. Ouellet Canada Inc.
12. QMark.
13. Rosemex Products.
14. Trane.
15. USA Coil & Air.

2.2 DESCRIPTION

A. Factory-assembled and -tested unit complying with AHRI 440.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.3 PERFORMANCE REQUIREMENTS

A. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
B. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

C. Seismic Performance: Cabinet unit heaters shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
   1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified."

2.4 COIL SECTION INSULATION

A. Insulation Materials: ASTM C 1071; surfaces exposed to airstream shall have aluminum foil facing to prevent erosion of glass fibers.
   1. Thickness: 1 inch.
   2. Thermal Conductivity (k-Value): 0.26 Btu x in./h x sq. ft. at 75 deg F mean temperature.
   3. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.
   4. Adhesive: Comply with ASTM C 916 and with NFPA 90A or NFPA 90B.
   5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

B. Insulation Materials: Comply with NFPA 90A or NFPA 90B. Unicellular polyethylene thermal plastic, preformed sheet insulation complying with ASTM C 534, Type II, except for density.
   1. Thickness: 1/2 inch.
   2. Thermal Conductivity (k-Value): 0.24 Btu x in./h x sq. ft. at 75 deg F mean temperature.
   3. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM C 411.
   4. Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.
   5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

2.5 CABINETS

A. Material: Steel with baked-enamel finish with manufacturer's standard paint, in color selected by Architect.
   1. Vertical Unit, Exposed Front Panels: Minimum 0.0677-inch- thick sheet steel, removable panels with channel-formed edges secured with tamperproof cam fasteners.
   2. Horizontal Unit, Exposed Bottom Panels: Minimum 0.0677-inch- thick sheet steel, removable panels secured with tamperproof cam fasteners and safety chain.
   3. Recessed Flanges: Steel, finished to match cabinet.
   4. Control Access Door: Key operated.
   5. Base: Minimum 0.0528-inch- thick steel, finished to match cabinet, 4 inches high with leveling bolts.
   6. Extended Piping Compartment: 8-inch- wide piping end pocket.
2.6 FILTERS

A. Minimum Arrestance: According to ASHRAE 52.1 and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
   1. Glass Fiber Treated with Adhesive: 80 percent arrestance and MERV 5.

2.7 COILS

A. Hot-Water Coil: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch and rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 220 deg F. Include manual air vent and drain.

2.8 CONTROLS

A. Fan and Motor Board: Removable.
   1. Fan: Forward curved, double width, centrifugal, directly connected to motor; thermoplastic or painted-steel wheels and aluminum, painted-steel, or galvanized-steel fan scrolls.
   3. Wiring Terminations: Connect motor to chassis wiring with plug connection.

B. Control devices and operational sequences are specified in Section 23 09 23 "Direct Digital Control (DDC) System for HVAC" and Section 23 09 93.11 "Sequence of Operations for HVAC DDC."

C. Electrical Connection:
   1. Factory-wired motors and controls for a single field connection.
   2. Provide transformer as needed for 277V power supplied to unit.

2.9 CAPACITIES AND CHARACTERISTICS

A. Cabinet: As scheduled.
      a. Top: Sloped.
      b. Air Inlet: Front, punched louver.
      c. Air Outlet: Top.
      a. Top: Flat.
      b. Air Inlet: Front,
      c. Air Outlet: Front, punched louver.
   3. Horizontal, Fully Recessed:
      a. Air Inlet: , punched louver.
      b. Air Outlet: , punched louver.
B. Fan:
   1. As Scheduled.

C. Heating Capacity:
   1. As Scheduled.

D. Hot-Water Heating Coil:
   1. As Scheduled.

E. Electrical Characteristics for Single-Point Connection:
   1. As Scheduled.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive cabinet unit heaters for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for piping and electrical connections to verify actual locations before unit-heater installation.

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

3.2 INSTALLATION

A. Install wall boxes in finished wall assembly; seal and weatherproof. Joint-sealant materials and applications are specified in Section 07 92 00 "Joint Sealants."

B. Install cabinet unit heaters to comply with NFPA 90A.

C. Suspend cabinet unit heaters from structure with elastomeric hangers.

D. Install wall-mounted thermostats and switch controls in electrical outlet boxes at heights to match lighting controls. Verify location of thermostats and other exposed control sensors with Drawings and room details before installation.

E. Install new filters in each fan-coil unit within two weeks of Substantial Completion.

3.3 CONNECTIONS

A. Piping installation requirements are specified in Section 23 21 13 "Hydronic Piping," Section 23 21 16 Hydronic Piping Specialties," Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to machine to allow service and maintenance.
C. Connect piping to cabinet unit heater's factory, hot-water piping package. Install the piping package if shipped loose.

D. Connect supply and return ducts to cabinet unit heaters with flexible duct connectors specified in Section 23 33 00 "Air Duct Accessories."

E. Comply with safety requirements in UL 1995.

F. Unless otherwise indicated, install union and gate or ball valve on supply-water connection and union and calibrated balancing valve on return-water connection of cabinet unit heater. Hydronic specialties are specified in Section 23 21 13 "Hydronic Piping" and Section 23 21 16 Hydronic Piping Specialties."

G. Ground equipment according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."

H. Connect wiring according to Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections[with the assistance of a factory-authorized service representative]:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
2. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.

B. Units will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

END OF SECTION 23 82 39.13