DIVISION 15 – MECHANICAL INDEX SHEET

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APPLICABLE PROVISIONS OF BIDDING REQUIREMENTS, PROJECT GUIDELINES AND GENERAL REQUIREMENTS (DIVISION 01) APPLY TO THE WORK SPECIFIED IN THESE SECTIONS.

SECTION 15010 - BASIC MECHANICAL REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes general administrative and procedural requirements for mechanical installations. The following administrative and procedural requirements are included in this Section to expand the requirements specified in Division 1.

1. General Mechanical Provisions
2. Codes, ordinances, permits, fees, or assessments
3. Submittals
4. Record Documents
5. Maintenance Manuals
6. Delivery, storage, and handling
7. Rough-ins
8. Cutting and Patching
9. Substitutions
10. Temporary utilities
11. Infection control requirements

1.2 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this and the other sections of Division 15. Each Division 15 Section applies where applicable to all other Division 15 Sections.

1.3 GENERAL MECHANICAL PROVISIONS

A. The work in this Division consists of furnishing all labor and materials, accessories, equipment, transportation, supervision, start-up services, instructions, permits and incidentals, and related items necessary to complete installation and successfully test, start-up and operate, in a practical and efficient manner, all mechanical work and systems indicated on the drawings and described in each Section of this Division. The work shall also include any items which, while not specifically included in these specifications or drawings, are reasonable and properly inferable there from or are accepted trade practice or necessary for the proper completion of this System.

B. The General Requirements of these specifications govern all portions of this heating, ventilating and plumbing system and will apply in full force to this contract. These Contractors shall, therefore, consider them as forming an integral part of this contract.

C. Submission of a Bid Proposal is considered evidence that a contractor has visited the site, examined the drawings and specifications of all Trades and has fully informed himself as to project and site conditions and is proficient, experienced and knowledgeable of all state, local and federal standards, codes, ordinances, permits and regulations which affect every subcontractor trade's completion, cost and time required and that all costs are included in his Bid Proposal.

D. The Contractor shall be responsible for all Subcontractors and suppliers, and shall include in his Bid Proposal and properly apportion, all materials, labor and equipment to the Subtrades.

E. All labor, materials and equipment shall be guaranteed by the Contractor and/or warranted by the manufacturer for one calendar year after date of final acceptance, except where specific, longer periods are specified. Make all necessary alterations, repairs, adjustments and replacements during guarantee period as directed by Engineer to comply with drawings and specifications. Such work shall be at no cost to the Owner.

F. Provide the service of factory-trained personnel for such periods of time as required to instruct the Owner's personnel on operation and maintenance of installed equipment.

G. This Contractor shall have in charge of the work at all times during construction a thoroughly competent Field Superintendent with experience in the work to be installed under this contract.

H. Where a conflict exists between the drawings and specifications it shall be immediately brought to the engineers attention. If such a conflict is not resolved before work commences, contractor shall provide the most work of greatest value.

I. All products shall be installed per the manufacturers written instructions. Where a conflict exists between the contract documents and the manufacturers' instructions, the engineer shall be notified immediately to resolve the conflict.

J. Refer to architectural specifications for infection control procedures

1.4 CODES, ORDINANCES, PERMITS, FEES OR ASSESSMENTS

A. All work and materials shall be installed in accordance with the standards as described by local and state codes or ordinances including the rules of the Michigan Plumbing Code, National Fire Protection Association, American Standards Association, and with the prevailing rules and regulations pertaining to adequate protection and guarding of any moving parts or otherwise hazardous locations.

B. Should the drawings or specifications call for sizes and grades different than required by the governing code, this Contractor shall furnish and install the larger size of the higher grade.

C. In addition, this Contractor shall give all notices, file all drawings, obtain all necessary approvals, obtain all permits, pay for all fees, deposits and expenses required for installation of all work under this contract, as stated therein and in the General Requirements. In such instances where permits are not required, the contractor shall engage a third party, preferably the local official, to inspect the work.

D. In addition to all applicable federal, state and local codes, the standards and codes listed below shall apply to all mechanical work. Where standards or codes are mentioned in these specifications, the latest edition or revision shall be followed; hence, the specified numbers may be superseded by new numbers.

1. American National Standard Institute (ANSI)
2. American Society for Testing Materials (ASTM)
3. American Society of Mechanical Engineers (ASME)
4. American Water Works Association (AWWA)
5. Air Moving and Condition Association, Inc. (AMCA)
6. Air Diffusion Council (ADC)

7. American Society Heating, Ventilating and Refrigerating and Air Conditioning Engineers (ASHRAE)
8. National Electrical Manufacturer's Association (NEMA)
9. American Refrigeration Institute (ARI)
10. ANSI Code of Pressure Piping and Unfired Pressure Vessels
11. Cast Iron Soil Pipe Institute
12. Underwriter's Laboratories (U.L.)
13. National Fire Protection Association (NFPA)
14. American Gas Association (AGA)
15. Michigan Occupational Safety and Health Acts (MIOSHA)
16. Sheet Metal and Air Conditioning National Association (SMACNA)
17. Michigan 2012 Mechanical Code
18. Michigan 2012 Plumbing Code
19. Michigan 2012 Building Code
20. ASHRAE Standard 90.1
21. ASME
22. International Fuel Gas Code

1.5 SUBMITTALS

A. General

1. Follow the procedures specified in Division 1 Section, Submittal Procedures.

1.6 RECORD DOCUMENTS

A. Prepare record documents in accordance with the requirements in Division 1 Section, Closeout Procedures. In addition to the requirements specified in Division 1, indicate the following installed conditions:

1. Ductwork mains and branches, size and location, for both exterior and interior; locations of dampers and other control devices; filters, boxes, and terminal units requiring periodic maintenance or repair.
2. Mains and branches of piping systems, with valves and control devices located and numbered, concealed unions located, and with items requiring maintenance located (i.e., traps, strainers, expansion compensators, tanks, etc.). Valve location diagrams, complete with valve tag chart. Indicate actual inverts and horizontal locations of underground piping.
3. Approved substitutions, Contract Modifications, and actual equipment and materials installed.
4. Contract Modifications, actual equipment and materials installed.

1.7 MAINTENANCE MANUALS

A. Prepare maintenance manuals in accordance with Division 1 Section, Closeout Procedures. In addition to the requirements specified in Division 1, include the following information for equipment items:

1. Description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of replacement parts.

2. Manufacturer's printed operating procedures to include start-up, break-in, and routine and normal operating instructions; regulation, control, stopping, shutdown, and emergency instructions; and summer and winter operating instructions.
3. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.
4. Servicing instructions and lubrication charts and schedules.

1.8 MANUFACTURERS

A. Refer to Division 1 section, “Product Requirements.”

B. Manufacturers and model numbers of products on which the design was based are listed either in the drawings or specifications. Manufacturers known to have products of equivalent quality and function are listed in the specification sections. Products by these manufacturers may be included in this contractor’s base bid if the product dimensions are similar to the basis of design and all other requirements of the specifications are met. This Contractor shall be considered liable for all added costs both to himself and others (including those costs as incurred by the Engineer, for redesigning or redrawing) resultant from the use of products not the basis of the design.

1.9 SUBSTITUTIONS

A. Refer to Division 1 Section, “Product Requirements.”

B. This Contractor shall be considered liable for all added costs both to himself and others (including those costs as incurred by the Engineer, for redesigning or redrawing) resultant from the substitution of products not the basis of the design.

C. This Contractor shall be responsible for the verification of adequate space (considering dimensions, required clearances, weights, and roughing-in requirements) for the installation of items or systems not the basis of the design. He shall be responsible for advising all other trades. He shall submit revised drawing layouts for the approval of the Engineer and shall not proceed without this approval.

1.10 TEMPORARY UTILITIES

A. Mechanical Contractor shall use existing outside sill cocks for temporary water.

B. Mechanical Contractor shall be responsible for all temporary heat and all associated costs.

1. Heating Equipment: Unless Owner authorizes use of permanent heating system, provide vented, self-contained, liquid-propane-gas or fuel-oil heaters with individual space thermostatic control.
2. Heating Units: Listed and labeled for type of fuel being consumed, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.11 INFECTION CONTROL REQUIREMENS

A. Maintain negative air pressure, as compared to adjacent Owner occupied areas, within the construction area at all times by utilizing existing dedicated exhaust fans as indicated on the mechanical drawings or by auxiliary fans which are exhausted directly to the exterior atmosphere.

Ensure location of exhaust discharge is not in close proximity to existing air intakes and operable windows. Owner will provide monitoring or pressure differential. Provide filters on existing intakes throughout construction to clean intake air. Replace filters on a weekly basis.

B. Provide intake fans with HEPA filters in Ante rooms. Fans shall maintain a positive pressure in the Ante room at all times.

PART 2 - EXECUTION

2.1 CUTTING AND PATCHING

A. Perform cutting and patching in accordance with Division 1 Section, Cutting and Patching. In addition to the requirements specified in Division 1, the following requirements apply:

1. Protection of Installed Work: During cutting and patching operations, protect adjacent installations.
2. Refer to drawing notes.

B. Perform cutting, fitting and patching of mechanical equipment and materials required to:

1. Uncover work to provide for installation of ill-time work.
2. Remove and replace defective work.
3. Remove and replace work not conforming to requirements of the Contract Documents.
4. Remove samples of installed work as specified for testing.
5. Install equipment and materials in existing structures.
6. Cut, channel, chase and drill floors, wells, partitions, ceilings and other surfaces necessary for mechanical installations. Perform cutting by skilled mechanics of the trades involved.
7. Upon written instructions from the Architect, uncover and restore work to provide for Architect/Engineer observation of concealed work.

C. Cut, remove and legally dispose of selected mechanical equipment, components and materials as indicated, including but not limited to removal of mechanical piping, heating units, plumbing fixtures and trim, and other mechanical items made obsolete by the new work.

D. Protect the structure, furnishings, finishes and adjacent materials not indicated or scheduled to be removed.

E. Provide and maintain temporary partitions or dust barriers adequate to prevent the spread of dust and dirt to adjacent areas.

F. Patch existing finished surfaces and building components using new materials matching existing materials and utilizing experienced installers. Installers' qualifications refer to the materials and methods required for the surface and building components being patched.

END OF SECTION

SECTION 15050 - BASIC MECHANICAL MATERIALS AND METHODS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following basic mechanical materials and methods to complement other Division 15 Sections.

1. Sequencing and scheduling requirements common to all division 15 specification sections.
2. Piping materials and installation instructions common to most piping systems.
3. Concrete equipment base construction requirements.
4. Equipment nameplate data requirements.
5. Condensate

B. Pipe and pipe fitting materials are specified in piping system Sections.

1.2 DEFINITIONS

A. Pipe, pipe fittings and piping include tube, tube fittings and tubing.

B. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below the roof, spaces above ceilings, unexcavated spaces, crawl spaces, and tunnels.

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

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

E. Concealed Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include rooftop locations.

F. 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. General: Submit the following according to the Conditions of the Contract and Division 1 Specification Sections.

B. Product data for following piping specialties:

1. Mechanical sleeve seals
2. Identification materials and devices
3. Fire Stopping Materials
4. Access Panels

C. Samples of color, lettering style, and other graphic representation required for each identification

material and device.

D. Shop drawings detailing fabrication and installation for metal and wood supports and anchorage for mechanical materials and equipment.

E. Welder certificates signed by contractor certifying that welders comply with requirements specified under the Quality Assurance Article.

1.4 QUALITY ASSURANCE

A. Qualify welding processes and operators for piping according to ASME Boiler and Pressure Vessel Code, Section IX, Welding and Brazing Qualifications.

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

B. ASME A13.1 for lettering size, length of color field, colors and viewing angles of identification devices.

C. Equipment Selection: Equipment of greater or larger power, dimensions, capacities and ratings may be furnished provided such proposed equipment is approved in writing and connecting mechanical and electrical services, circuit breakers, conduit, motors, bases and equipment spaces are increased. No additional costs will be approved for these increases if larger equipment is approved. If minimum energy ratings or efficiencies of the equipment are specified, the equipment must meet the design requirements and commissioning requirements.

1.5 DELIVERY, STORAGE AND HANDLING

A. Deliver products to the project properly identified with names, model numbers, types, grades, compliance labels, and other information needed for identification.

B. Products stored on site shall be protected from damage. If products are intended for interior installation they shall be kept dry while in storage. Any damage caused by improper storage shall be corrected at the contractors expense.

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

D. Protect stored pipes and tubes from moisture and dirt. Elevate above grade. When stored inside, do not exceed structural capacity of the floor.

E. Protect flanges, fittings and pipe specialties from moisture and dirt.

F. Protect stored plastic pipes from direct sunlight. Support to prevent sagging and bending.

1.6 SEQUENCING AND SCHEDULING

A. Coordinate mechanical equipment installation with other building components.
B. Arrange for chases, slots and openings in building structure during progress of construction to allow for mechanical installations.

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

D. Sequence, coordinate and integrate installations of mechanical materials and equipment for efficient flow of the work. Coordinate installation of large equipment requiring positioning before closing in the building.

E. Coordinate connection of electrical services.

F. Coordinate connection of mechanical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies.

G. Coordinate requirements for access panels and doors where mechanical items requiring access are concealed behind finished surfaces. Access panels and doors are specified in Division 8 Section, Access Doors.

H. Coordinate installation of identifying devices after completing covering and painting where devices are applied to surfaces. Install identifying devices prior to installing acoustical ceilings and similar concealment.

1.7 FIRE STOP SYSTEMS

A. Mechanical Contractor shall furnish and install all fire stop systems required at all piping penetrations through rated walls and floors.

B. For penetrations by combustible items (penetrants consumed by high heat aflame) including insulated metal pipe, PVC jacketed, flexible cable or cable bundles and plastic pipe (closed piping systems) the following materials are accepted:

1. Hilti FS ONE High Performance Intumescent Firestop Sealant.
2. Hilti CP 618 Firestop Putty.
3. Hilti CP 642 Firestop Jacket.
4. Hilti CP 643 Firestop Jacket.
5. 3M Fire Barrier CP25 WB.
6. 3M Fire Barrier FS 195 Wrap.Strip.
7. Tremco Tremstop WBM Intumescent Firestop Sealant.

C. For penetrations by combustible plastic pipe (open piping systems), the following materials are acceptable:

1. Hilti CP 642 Firestop Jacket.
2. Hilti CP 643 Firestop Jacket.
3. Hilti FS ONE High Performance Intumescent Firestop Sealant.
4. 3M Fire Barrier PPO Plastic Pipe Device.

D. For large size/complex penetrations made to accommodate cable trays, multiple steel and copper pipes, electrical busways in raceways' the following materials are acceptable:

1. Hilti FS 635 Trowelable Firestop Compound.
2. Hilti FIRE BLOCK.
3. 3M Firestop Foam 2001.
4. 3M Fire Barrier CS 195 Composite Sheet.

E. For openings between structurally separate sections of wall and floors. Top of walls, the following materials are acceptable:

1. Hilti FS 60t Elastomeric Firestop Sealant.
2. Hilti CP 601s Elastomeric Firestop Sealant.
3. Hilti CP 606 Flexible Firestop Sealant.
4. Hilti FS ONE High Performance Intrumescent Firestop Sealant.
5. 3M Fire Barrier CP 25 WB.

F. Provide a firestop system with a “F” rating as determined by UL 1479 or ASTM E814 which is equal to the time rating of construction being penetrated.

G. Provide a firestop system with an Assembly Rating as determined by UL 2079 which is equal to the time rating of construction being penetrated.

H. Firestopping at valve boxes.

1. Hilti CP 618 Firestop Putty Stick.
2. Hilti CP 617 and CP 617L Firestop Putty Pad.

I. For pipe penetrations of cast in place concrete floors and concrete over metal decking the following material is acceptable:

1. Hilti CP 680 Cast-in Firestop Device (No equal).

PART 2 - PRODUCTS

2.1 PIPE AND PIPE FITTINGS

A. Refer to individual piping system specifications Sections for pipe 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 piping system specification sections in Division 15 for special joining materials not listed below.

B. Solder Filler Metal: ASTM B 32.

1. Alloy Sn95 or Alloy Sn94: Tin (approximately 95 percent) and silver (approximately 5 percent), having 0.10 percent lead content.

2. Alloy Sn50: Tin (50 percent) and lead (50 percent). For non-potable pipe use only.
3. Alloy E: Tin (approximately 95 percent) and copper (approximately 5 percent) having 0.10 maximum lead content.
4. Alloy HA: Tin-antimony-silver-copper-zinc, having 0.10 percent maximum lead content.
5. Alloy HB: Tin-antimony-silver-copper-nickel, having 0.10 percent maximum lead content.

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

D. Solvent Cements: Manufacturer's standard solvents complying with the following:

1. Acrylonitrile-Butadiene-Styrene (ABS): ASTM D 2235.
2. Chlorinated Poly (Vinyl Chloride) (CPVC): ASTM F 493.
3. Poly (Vinyl Chloride) (PVC): ASTM D 2564.
4. PVC to ABS Transition: Made to requirements of ASTM D 3138, color other than orange.

E. Couplings: Iron body sleeve assembly, fabricated to match outside diameters of plain-end pressure pipes.

1. Sleeve: ASTM A 126, Class B, gray iron
2. Followers: ASTM A 47 (ASTM A 47M), Grade 32510 or ASTM A 536 ductile iron
3. Gaskets: Rubber
4. Bolts and Nuts: AWWA C111
5. Finish: Enamel paint

2.3 PIPING SPECIALTIES

A. Escutcheons: Manufactured wall, ceiling and floor plates; deep-pattern type where required to conceal protruding fittings and sleeves.

1. Inside Diameter: Closely fit around pipe, tube, and insulation.
2. Outside Diameter: Completely cover opening.
3. Stamped Steel: Split-plate, with concealed hinge, spring clips, and chrome-plated finish.

B. Dielectric Fittings: Assembly or fitting having insulating material isolating joined dissimilar metals to prevent galvanic action and stop corrosion.

1. Description: Combination of copper alloy and ferrous; threaded, solder, plain, and weld neck end types and matching piping system materials.
2. Insulating Material: Suitable for system fluid, pressure, and temperature.
3. Dielectric Couplings: Galvanized-steel coupling, having inert and non-corrosive thermoplastic lining, with threaded ends and 300-psig minimum working pressure at 225 degrees F temperature.
4. Dielectric Nipples: Electroplated steel nipple, having inert and non-corrosive thermoplastic lining, with combination of plain, threaded, or grooved end types and 300-psig minimum working pressure at 225 degrees F temperature.

C. Sleeves: The following materials are for wall, floor, slab and roof penetrations:

1. Steel Sheet-Metal: 24-gauge or heavier galvanized sheet metal, round tube closed with welded longitudinal joint.
2. Steel Pipe: ASTM A 53, Type E, Grade A, Schedule 40, galvanized plain ends.

3. Underdeck Clamp: Clamping ring with set screws.

2.4 IDENTIFYING DEVICES AND LABELS

A. General: Manufacturer's standard products of categories and types required for each application as referenced in other Division 15 Sections. Where more than one type is specified for listed application, selection is Installer's option, but provide single selection for each product category.

B. Equipment Nameplates: Metal nameplate with operational data engraved or stamped, permanently fastened to equipment.

1. Data: Manufacturer, product name, model number, serial number, capacity, operating and power characteristics, labels of tested compliances and similar essential data.
2. Location: An accessible and visible location.

C. Stencils: Standard stencils, prepared for required applications with letter sizes conforming to recommendations of ASME A13.1 for piping and similar applications, but not less than 1-1/4 inch high letters for ductwork and not less than ¾ inch high letters for access door signs and similar operational instructions.

1. Material: Fiberboard.
2. Stencil Paint: Standard exterior type stenciling enamel; black, except as otherwise indicated, either brushing grade or pressurized spray-can form and grade.
3. Identification Paint: Standard identification enamel of colors indicated or, if not otherwise indicated for piping systems, comply with ASME A13.1 for colors.

D. Snap-On Plastic Pipe Markers: Manufacturer's standard pre-printed, semi-rigid snap-on, color-coded, pressure-sensitive vinyl pipe markers, conforming to ASME A13.1.

E. Engraved Plastic-Laminate Signs: ASTM D 709, Type I, cellulose, paper-base, phenolic-resin-laminate engraving stock; Grade ES-2, black surface, black phenolic core, with white (letter color) melamine subcore, except when other colors are indicated.

1. Fabricate in sizes required for message.
2. Engraved with engraver's standard letter style, of sizes and with working to match equipment identification.
3. Punch for mechanical fastening.
4. Thickness: 1/8-inch, except as otherwise indicated.
5. Fasteners: Self-tapping stainless-steel screws.

F. Plastic Equipment Markers: Laminated-plastic, color-coded equipment markers. Conform to following color code:

1. Green: Cooling equipment and components.
2. Yellow: Heating equipment and components.
3. Yellow/Green: Combination cooling and heating equipment and components.
4. Nomenclature: Include following, matching terminology on schedules as closely as possible:

a. Name and plan number.
b. Equipment service.

G. Lettering and Graphics: Coordinate names, abbreviations, and other designations used in mechanical identification, with corresponding designations indicated. Use numbers, lettering, and wording indicated for proper identification and operation/maintenance of mechanical systems and equipment.

1. Multiple Systems: Where multiple systems of same generic name are indicated, provide identification that indicates individual system number as well as service such as "Boiler No. 3," "Air Supply No. 1H," or "Standpipe F12."

2.5 GROUT

A. Non-shrink, Nonmetallic Grout: ASTM C 1107, Grade B

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

2.6 FIRE STOP SYSTEMS

A. Elastomeric Firestop Sealant

1. Metal Pipe
2. Where pipe movement or vibration is expected
3. Construction joints

B. Intumesent Firestop Sealant

1. Plastic pipes – closed or vented piping systems
2. Single and bundled cables
3. Insulated metal pipes

C. High Performance Firestop Sealant

1. Metal pipe – static conditions and sleeved openings

D. Trowlable Firestop Compound

1. Large openings

a. Cable trays
b. Electrical busway
c. Multiple metal pipes

E. Fire Barrier Collar

1. Plastic pipe – 3 inch, 4 inch, 5 inch and 6 inch

F. Approved Supplies

1. Must be approved by State Fire Marshals Office

a. Hilti, Firestop Systems
b. Fire Protection Systems, Incorporated

2.7 ACCESS PANELS

A. Refer to Division 8 Section, “Access Doors and Frames.”

B. Provide access doors as follows:

1. Wherever valves, traps, strainers, filters, dampers, humidifiers, control devices, or other items which require service are located above fixed suspended ceilings, or are concealed in walls, provide approved 18 inch by 18 inch steel access panels, flush type, for mounting in ceilings and walls as indicted and/or required. Locate to provide access for all required maintenance. Provide more than one where required.
2. Mechanical trades shall furnish for installation by the General Trades unless otherwise noted.

PART 3 - EXECUTION

3.1 ROUGH-IN

A. Verify final locations for rough-ins with field measurements and with requirements of the actual equipment to be connected.

B. Refer to equipment specifications in Divisions 2 through 16 for rough-in requirements.

3.2 PIPING SYSTEMS - COMMON REQUIREMENTS

A. Install piping as described below, except where system Sections specify otherwise. Individual piping system specification sections in Division 15 specify piping installation requirements unique to the piping system.

B. General Locations and Arrangements: Drawings (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.

C. Install piping at indicated slope.

D. Install components having pressure rating equal to or greater than system operating pressure.

E. Install piping in concealed interior and exterior locations, except in equipment rooms and service areas.

F. Install piping free of sags and bends.

G. Install exposed interior and exterior piping at right angles or parallel to building walls. Diagonal runs are prohibited, except where indicated.

H. Install piping tight to slabs, beams, joists, columns, walls, and other building elements. Allow sufficient space above removable ceiling panels to allow for ceiling panel removal.

I. Install piping to allow application of insulation plus 1-inch clearance around insulation.

J. Locate groups of pipes parallel to each other, spaced to permit valve servicing.

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

L. Install couplings according to manufacturer's printed instructions.

M. Install pipe escutcheons for pipe penetrations of concrete and masonry walls, wall board partitions, and suspended ceilings according to the following:

1. Uninsulated Piping Wall Escutcheons: Stamped steel
2. Uninsulated Piping Floor Plates in Utility Areas: Cast-iron floor plates
3. Insulated Piping: Stamped steel, with concealed hinge, spring clips, and chrome-plated finish
4. Piping in Utility Areas: Stamped-steel, with set-screw or spring clips

N. Sleeves are not required for core drilled holes.

O. Permanent sleeves are not required for holes formed by PE plastic (removable) sleeves.

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

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

   a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring where specified.
   b. Build sleeves into new walls and slabs as work progresses.
   c. Install large enough sleeves to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:

      - PVC Pipe Sleeves: For pipes smaller than 6 inches.
      - Steel Pipe Sleeves: For pipes smaller than 6 inches.
      - Steel Sheet-Metal Sleeves: For pipes 6 inches and larger that penetrate gypsum-board partitions.
      - Cast-iron Sleeve Fittings: For floors having membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level . Flashing is specified in Division 7 Section, Flashing and Sheet Metal.
      - Seal space outside of sleeve fittings with non-shrink, nonmetallic grout.

2. Below Grade, Exterior Wall, Pipe Penetrations: Furnish cast-iron wall penetration system sleeves equal to "Link Seal". Install `according to manufacturer's printed installation instructions.
3. Fire Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings and floors at pipe penetrations. Seal pipe penetrations with firestopping sealant material specified in this section.
4. Piping Joint Construction: Join pipe and fittings as follows and as specifically required in individual piping system Sections.

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: Construct joints according to AWS, Soldering Manual, Chapter 22, The Soldering of Pipe and Tube.
d. 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 inside diameter. Join pipe fittings and valves as follows:

- Note the internal length of threads in fittings or valve ends, and proximity of internal seat or wall, to determine how far pipe should be threaded into joint.
- Apply appropriate tape or thread compound to external pipe threads (except where dry seal threading is specified).
- Damaged Threads: Do not use pipe or pipe fittings having threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

e. Welded Joints: Construct joints according to AWS D10.12, Recommended Practices and Procedures for Welding Low Carbon Steel Pipe, using qualified processes and welding operators according to the Quality Assurance Article.
f. Flanged Joints: Align flange surfaces parallel. Select appropriate gasket material, size, type and thickness for service application. Install gasket concentrically positioned. 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 using torque wrench.
g. Plastic Pipe and Fitting Solvent-Cement Joints: Clean and dry joining surfaces by wiping with clean cloths or paper towels. Join pipe and fittings according to the following standards:

- Comply with ASTM F 402 for safe handling of solvent-cement and primers.
- Poly (Vinyl Chloride) (PVC) Non-Pressure Application: ASTM D 2855
- PVC to ABS (Non-Pressure) Transition: Procedure and solvent cement described in ASTM D 3138.

h. Plastic Pipe and Fitting Heat-Fusion Joints: Prepare pipe and fittings and join with heat-fusion equipment according to manufacturer's printed instructions.

- Plain-End Pipe and Fittings: Butt joining
- Plain-End Pipe and Socket-Type Fittings: Socket joining

5. Piping Connections: Except as otherwise indicated, make piping connections as specified below:
a. Install unions in piping 2 inches and smaller adjacent to each valve and at final connection to each piece of equipment having a 2-inch or smaller threaded pipe connection.
b. Install flanges in piping 2½ inches and larger adjacent to flanged valves and at final connection to each piece of equipment having flanged pipe connection.
c. Dry Piping Systems (Gas): Install dielectric unions and flanges to connect piping materials of dissimilar metals.

d. Wet Piping Systems (Water): Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals.
Where piping is indicated to be installed below floor slab, it shall be within a PVC sleeve sized to accommodate piping and insulation.

3.3 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to provide the maximum possible headroom where mounting heights are not indicated.

B. Install equipment according to approved submittal data. Portions of the work are shown only in diagrammatic form. Refer conflicts to the Architect.

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

D. Install mechanical equipment to facilitate servicing, maintenance and repair or replacement of equipment components. Connect equipment for ease of disconnecting, with minimum of interference with other installations. Extend grease fittings to an accessible location.

E. Install equipment giving right-of-way to piping systems installed at a required slope.

F. Coordinate mechanical systems, equipment and materials installation with other building components.

G. Verify all dimensions by field measurements.

H. Arrange for chases, slots, and openings in other building components during progress of construction, to allow for mechanical installations.

I. Coordinate the installation of required supporting devices and sleeves to be set in poured-in-place concrete and other structural components, as they are constructed.

J. Sequence, coordinate, and integrate installations of mechanical materials and equipment for efficient flow of the work. Give particular attention to large equipment requiring position prior to closing in the building.

K. Coordinate connection of mechanical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies. Provide required connection for each service.

3.4 LABELING AND IDENTIFYING

A. Piping Systems: Install pipe markers on each system. Include arrows showing normal direction of flow.

1. Stenciled Markers: Complying with ASME A13.1.
2. Locate pipe markers wherever piping is exposed in finished spaces, machine rooms, accessible maintenance spaces (shafts, tunnels, plenums), and exposed exterior locations as follows (near shall be interpreted to mean "in-sight-of):

a. Near each valve and control device.
b. Near each branch, excluding short take-offs for fixtures and terminal units. Mark each pipe at branch, where flow pattern is not obvious.
c. Near locations where pipes pass through walls, floors, ceilings, or enter inaccessible enclosures.
d. At access doors, manholes, and similar access points that permit view of concealed piping.
e. Near major equipment items and other points of origination and termination.
f. Spaced at a maximum of 50-foot intervals along each run. Reduce intervals to 25 feet in congested areas of piping and equipment.
g. On piping above removable acoustical ceilings.

3. Equipment: Install engraved plastic laminate sign or equipment marker on or near each major item of mechanical equipment.
4. Adjusting: Relocate identifying devices, which become visually blocked by work of this Division or other Divisions.

B. Valve Tags

1. Install brass tags chained to handwheel of all valves and stop cocks (except drain valves). Each tag to be stamped with a number to identify system and unit served.
2. Provide typewritten directory with numbers corresponding to numbers on valve tags. Numbers indicating system and unit or devices serviced or controlled by particular valve. Mount directory in wooden frame with glass face. Locate as directed by the Architect.

3.5 PAINTING AND FINISHING

A. Refer to Division 9 Section, “Interior Painting”, for field painting requirements.

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

C. All exposed ducts and pipes in finished areas shall be painted by the General Contractor.

3.6 CONCRETE BASES

A. Construct concrete equipment bases of dimensions indicated, but not less than 4 inches larger than supported unit in both directions. Follow supported equipment manufacturer's setting templates for anchor bolt and tie locations. Use 3000-psi, 28-day compressive strength concrete and reinforcement as specified in Division 3 Section, Cast-In-Place Concrete.

3.7 ERECTION OF METAL SUPPORTS AND ANCHORAGE

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

B. Field Welding: Comply with AWS D1.1, Structural Welding Code - Steel.

3.8 ERECTION OF WOOD SUPPORTS AND ANCHORAGE

A. Cut, fit and place wood grounds, nailers, blocking and anchorage to support and anchor mechanical

materials and equipment.

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

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

3.9 DEMOLITION

A. Disconnect, demolish and remove work specified under Division 15 and as indicated.

B. Where pipe, ductwork, insulation, or equipment to remain is damaged or disturbed, remove damaged portions and install new products of equal capacity and quality.

C. Accessible Work: Remove indicated exposed pipe and ductwork in its entirety.

D. Abandoned Work: Cut and remove buried pipe abandoned in place, 2 inches beyond the face of adjacent construction. Cap and patch surface to match existing finish.

E. Removal: Remove indicated equipment from the project site.

F. Temporary Disconnection: Remove, store, clean, reinstall, reconnect and make operational equipment indicated for relocation.

3.10 GROUTING

A. Install nonmetallic non-shrink grout for mechanical equipment base bearing surfaces, pump and other equipment base plates, and anchors. Mix grout according to manufacturer's printed instructions.

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

C. Provide forms for placement of grout, as required.

D. Avoid air entrapment when placing grout.

E. Place grout to completely fill equipment bases.

F. Place grout around anchors.

G. Cure placed grout according to manufacturer's printed instructions.

END OF SECTION

SECTION 15055 - MOTORS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes basic requirements for motors. It includes motors that are factory-installed as part of equipment and appliances as well as field-installed motors.

1.2 QUALITY ASSURANCE

A. Comply with NFPA 70, National Electrical Code.

B. NRTL Listing: Provide NRTL listed motors.

1. Term "Listed": As defined in National Electrical Code, Article 100.

C. Comply with NEMA MG 1, Motors and Generators.

PART 2 - PRODUCTS

2.1 MOTORS, GENERAL

A. General: Requirements below apply to motors covered by this section except as otherwise indicated.

B. Motors 3/4 HP and Larger: Polyphase.

C. Motors Smaller Than 3/4 HP: Single-phase.

D. Frequency Rating: 60 Hz.

E. Capacity: Sufficient to start and operate connected loads at designated speeds in indicated environment, and with indicated operating sequence, without exceeding nameplate ratings. Provide motors rated for continuous duty at 100 percent of rated capacity.

F. Temperature Rise: Based on 40 degrees C ambient except as otherwise indicated.

G. Enclosure: Open dripproof.

2.2 POLYPHASE MOTORS

A. General: Squirrel-cage induction-type conforming to the following requirements except as otherwise indicated.

B. NEMA Design Letter Designation: B.

C. Multi-Speed Motors: Separate winding for each speed.

D. Internal Thermal Overload Protection for Motors: For motors so indicated, protection automatically opens control circuit arranged for external connection.

Protection operates when winding temperature exceeds safe value calibrated to the temperature rating of the motor insulation.

E. Bearings: Double-shielded, pre-lubricated ball bearings suitable for radial and thrust loading of the application.

F. Rugged Duty Motors: Totally enclosed with 1.25 minimum service factor. Provide motors with reasonable bearings and equipped with capped relieve vents. Insulate windings with non-hygroscopic material. External finish shall be chemical resistant paint over corrosion resistant primer. Provide integral condensate drains.

G. Motors for Reduced Inrush Starting: Coordinate with indicated reduced inrush controller type and with characteristics of driven equipment load. Provide required wiring leads in motor terminal box to suit control method.

2.3 SINGLE-PHASE MOTORS

A. General: Conform to the following requirements except as otherwise indicated.

B. Energy Efficient Motors: One of the following types as selected to suit the starting torque and other requirements of the specific motor application.

1. Permanent Split Capacitor.
2. Split-Phase Start, Capacitor-Run.
3. Capacitor-Start, Capacitor-Run.

C. Shaded-Pole Motors: Use only for motors smaller than 1/20 HP.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General: The following requirements apply to field-installed motors.

B. Install motors in accordance with manufacturer's published instructions and the following:

1. Belt Drive Motors: Use adjustable motor mounting bases. Align pulleys and install belts. Use belts identified by the manufacturer and tension belts in accordance with manufacturer recommendations.

3.2 COMMISSIONING

A. Check operating motors, both factory and field-installed, for unusual conditions during normal operation. Coordinate with the commissioning of the equipment for which the motor is a part.

B. Report unusual conditions.

C. Correct deficiencies of field-installed units.

END OF SECTION

SECTION 15060 - HANGERS & SUPPORTS FOR MECHANICAL EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes hangers and supports for mechanical systems piping and equipment.

1.2 DEFINITIONS

A. Terminology used in this section is defined in MSS SP-90.

1.3 SUBMITTALS

A. General: Submit the following according to the Conditions of the Contract and Division 1 Specification Sections.

1.4 QUALITY ASSURANCE

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

1. Certify that each welder has satisfactorily passed AWS qualification tests for welding processes involved and, if pertinent, has undergone recertification.

B. NFPA Compliance: Comply with NFPA 13 for hangers and supports used as components of fire protection systems.

C. International Plumbing and Mechanical Codes Compliance: Comply with International Plumbing and Electrical Codes for hanger spacing.

PART 2 - PRODUCTS

2.1 MANUFACTURED PRODUCTS

A. Hangers, Supports and Components: Factory-fabricated according to MSS SP-58.

1. Components include galvanized coatings where installed for piping and equipment that will not have a field-applied finish.
2. Pipe attachments include nonmetallic coating for electro-lytic protection where attachments are in direct contact with copper tubing.

B. Thermal-Hanger Shield Inserts: 100-psi average compressive strength, waterproofed calcium silicate, encased with sheet metal shield. Insert and shield cover entire circumference of pipe and are of length indicated by manufacturer for pipe size and thickness of insulation.

2.2 MISCELLANEOUS MATERIALS

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

B. Bolts and Nuts: ASME B18.10 or ASTM A 183, steel, hex-head, track bolts and nuts.

C. Washers: ASTM F 844, steel, plain, flat washers.

D. Grout: ASTM C 1107, Grade B, non-shrink, nonmetallic.

1. Characteristics include post-hardening, volume-adjusting, dry, hydraulic-cement-type grout that is non-staining, non-corrosive, non-gaseous and is recommended for interior and exterior applications.
2. Design Mix: 5000-psi, 28-day compressive strength.
3. Water: Potable.
4. Packaging: Premixed and factory-packaged.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT APPLICATIONS

A. Comply with MSS SP-69 for pipe hanger selections and applications that are not specified in piping specification sections.

3.2 HANGER AND SUPPORT INSTALLATION

A. General: Comply with MSS SP-69 and SP-89. Install hangers, supports, clamps and attachments as required to properly support piping for building structure.

B. Arrange for grouping of parallel runs of horizontal piping supported together on field-fabricated, heavy-duty trapeze hangers where possible.

C. Install supports with maximum spacings complying with MSS SP-69 and table below.

1.

Nominal Pipe Or Tube Size	STD WT STEEL PIPE				COPPER TUBE			
	WATER SERVICE		VAPOR SERVICE		WATER SERVICE		VAPOR SERVICE	
	Ft	M	Ft	M	Ft	M	Ft	m
¼	7	2.1	8	2.4	5	1.5	5	1.5
3/8	7	2.1	8	2.4	5	1.5	6	1.8
½	7	2.1	8	2.4	5	1.5	6	1.8
¾	7	2.1	9	2.7	5	1.5	7	2.1
1	7	2.1	9	2.7	6	1.8	8	2.4
1 ¼	7	2.1	9	2.7	6	2.1	9	2.7
1 ½	9	2.7	12	3.7	8	2.4	10	3.0
2	10	3.0	13	4.0	8	2.4	11	3.4
2 ½	11	3.4	14	4.3	9	2.7	13	4.0
3 & Up	12	3.7	15	4.6	10	3.0	14	4.3

2. Fiberglass Reinforced: Follow pipe manufacturer's recommendations for material and service condition.
3. Plastic: Follow pipe manufacturer's recommendations for material and service condition.

4. Cast Iron Soil: 10ft Max spacing; min. of one (1) hanger per pipe section close to joint on the barrel, also at change of direction and branch connections.
5. Ductile Iron Pipe: 20ft. Max spacing; min. of one (1) hanger per pipe section close to the joint behind the bell and at change of direction and branch connections. For pipe sizes six (6) inches and under, installed on ANSI B31 projects, that are subjected to loadings other than weight of pipe and contents, the span should be limited to the maximum spacing for water service steel pipe.
6. Follow requirements of the National Fire Protection Association.

D. Where pipes of various sizes are supported together by trapeze hangers, space hangers for smallest pipe size or install intermediate supports for smaller diameter pipes as specified above for individual pipe hangers.

E. Install building attachments within concrete or to structural steel. Space attachments within maximum piping span length indicated in MSS SP-69. Install additional attachments at concentrated loads, including valves, flanges, guides, strainers, expansion joints, and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten insert to forms. Install reinforcing bars through openings at top of inserts.

F. Install concrete inserts in new construction prior to placing concrete.

G. Install mechanical-anchor fasteners in concrete after concrete is placed and completely cured. Install according to fastener manufacturer's written instructions. Do not use in lightweight concrete slabs or in concrete slabs less than 4 inches thick.

H. Support fire protection systems piping independent of other piping.

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

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

K. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and so that maximum pipe deflections allowed by ASME B31.9, Building Services Piping, is not exceeded.

L. Insulated Piping: Comply with the following installation requirements.

1. Clamps: Attach clamps, including spacers (if any), to piping with clamps projecting through insulation; do not exceed pipe stresses allowed by ASME B31.9.
2. Saddles: Install protection saddles MSS Type 39 where insulation without vapor barrier is indicated. Fill interior voids with segments of insulation that match adjoining pipe insulation.
3. Shields: Install MSS Type 40, protective shields on cold piping with vapor barrier. Shields span an arc of 180 degrees and have dimensions in inches not less than the following:

NPS (Inches)	LENGTH	THICKNESS
1/4 to 3-1/2	12	0.048
4	12	0.060
5 and 6	18	0.060
8 to 14	24	0.075
16 to 24	24	0.105

4. Pipes 8 inches and Larger: Include wood inserts.
5. Insert Material: Length at least as long as the protective shield.
6. Thermal-Hanger Shields: Install with insulation of same thickness as piping.

3.3 EQUIPMENT SUPPORTS

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

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

3.4 ADJUSTING

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

3.5 PAINTING

A. Touching Up: Clean field welds and abraded areas of shop paint and paint exposed areas immediately after erection of 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 by brush or spray to provide a minimum dry film thickness of 2.0 mils.

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

END OF SECTION

SECTION 15081 - MECHANICAL INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes pipe, duct and equipment insulation.

1.2 DEFINITIONS

A. Hot Surfaces: Normal operating temperatures of 100 degrees F or higher.

B. Dual-Temperature Surfaces: Normal operating temperatures that vary from hot to cold.

C. Cold Surfaces: Normal operating temperatures less than 75 degrees F.

1.3 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification.

B. Product data for each type of mechanical insulation identifying k-value, thickness and accessories.

1.4 QUALITY ASSURANCE

A. Fire Performance Characteristics: Conform to the following characteristics for insulation including facings, cements and adhesives, when tested according to ASTM E-84, by UL or other testing or inspecting organization acceptable to the authority having jurisdiction. Label insulation with appropriate markings of testing laboratory.

1. Interior Insulation: Flame spread rating of 25 or less and a smoke developed rating of 50 or less.
2. Exterior Insulation: Flame spread rating of 75 or less and a smoke developed rating of 150 or less.

B. Install insulation per guidelines published by the Midwest Insulation Contractors Association.

1.5 SEQUENCING AND SCHEDULING

A. Schedule insulation application after testing piping and ducting systems.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Glass Fiber:
   CertainTeed Corporation
   Manville

Owens-Corning Fiberglass Corporation
USG Interiors, Inc. - Thermafiber Division

2. Calcium Silicate:
Manville
Owens-Corning Corporation

2.2 GLASS FIBER

A. Material: Inorganic glass fibers, bonded with a thermosetting resin.

B. Jacket: All-purpose, factory-applied, laminated glass-fiber-reinforced, flame-retardant kraft paper and aluminum foil having self-sealing lip.

C. Board: ASTM C 612, Class 2, semi-rigid jacketed board.

1. Thermal Conductivity: 0.26 average maximum at 75 degrees F mean temperature.
2. Density: 12 pcf average maximum.

D. Blanket: ASTM C 553, Type II, Class F-1, jacketed flexible blankets.

1. Thermal Conductivity: 0.32 average maximum at 75 degrees F mean temperature.

E. Preformed Pipe Insulation: ASTM C 547, Class 1, rigid pipe insulation, jacketed.

1. Thermal Conductivity: 0.26 average maximum at 75 degrees F mean temperature.
2. Density: 10 average maximum.

F. Adhesive: Produced under the UL Classification and Follow-up service.

1. Type: Non-flammable, solvent-based.
2. Service Temperature Range: Minus 20 to 180 degrees F.

G. Vapor Barrier Coating: Waterproof coating recommended by insulation manufacturer for outside service.

2.3 CALCIUM SILICATE

A. Material: ASTM C 533, Type I; inorganic, hydrous calcium silicate, non-asbestos fibrous reinforcement; incombustible.

B. Form: Molded flat block, curbed block, grooved block, and preformed pipe sections as appropriate for surface.

C. Thermal Conductivity: 0.60 at 500 degrees F.

D. Dry Density: 15.0 pcf maximum.

E. Compressive Strength: 60 psi minimum at 5 percent deformation.

F. Fire Performance Characteristics: Provide materials identical to those whose fire performance characteristics have been determined, per test method indicated below, by UL or other testing and inspecting organization acceptable to authorities having jurisdiction.

1. Test Method: ASTM E 84.
2. Flame Spread: 0.
3. Smoke Developed: 0.

2.4 INSULATING CEMENTS

A. Mineral Fiber: ASTM C 195.

1. Thermal Conductivity: 1.0 average maximum at 500 degrees F mean temperature.
2. Compressive Strength: 10 psi at 5 percent deformation.

B. Mineral Fiber, Hydraulic-Setting Insulating and Finishing Cement: ASTM C 449.

1. Thermal Conductivity: 1.2 average maximum at 400 degrees F mean temperature.
2. Compressive Strength: 100 psi at 5 percent deformation.

2.5 ADHESIVES

A. Flexible Elastomeric Cellular Insulation Adhesive: Solvent-based, contact adhesive recommended by insulation manufacturer.

B. Lagging Adhesive: MIL-A-3316C, non-flammable adhesive in the following Classes and Grades:

1. Class 1, Grade A for bonding glass cloth and tape to unfaced glass fiber insulation, sealing edges of glass fiber insulation, and bonding lagging cloth to unfaced glass fiber insulation.
2. Class 2, Grade A for bonding glass fiber insulation to metal surfaces.

2.6 JACKETS

A. General: ASTM C 921, Type 1, except as otherwise indicated.

B. PVC Jacketing: High-impact, ultra-violet-resistant PVC, 20-mils thick, roll stock ready for shop or field cutting and forming to indicated sizes.

1. Adhesive: As recommended by insulation manufacturer.

C. PVC Fitting Covers: Factory-fabricated fitting covers manufactured from 20-mil-thick, high-impact, ultra-violet-resistant PVC.

1. Adhesive: As recommended by insulation manufacturer.

2.7 ACCESSORIES AND ATTACHMENTS

A. Glass Cloth and Tape: Woven glass fiber fabrics, plain weave, pre-sized a minimum of 8 ounces per square yard.

1. Tape Width: 4 inches
2. Cloth Standard: MIL-C-20079H, Type I.
3. Tape Standard: MIL-C-20079H, Type II.

B. Bands: ¾ inches wide, in one of the following materials compatible with jacket:

1. Stainless Steel: Type 304, 0.020 inches thick.
2. Galvanized Steel: 0.005 inches thick.
3. Aluminum: 0.007 inches thick.
4. Brass: 0.01 inches thick.

C. Wire: 14-gauge nickel copper alloy, 16-gauge, soft-annealed stainless steel, or 16-gauge, soft annealed galvanized steel.

D. Corner Angles: 28-gauge, 1 inch by 1 inch aluminum adhered to 2 inch by 2 inch kraft paper.

E. Anchor Pins: Capable of supporting 20 pounds each. Provide anchor pins and speed washers of sizes and diameters as recommended by the manufacturer for insulation type and thickness.

2.8 SEALING COMPOUNDS

A. Vapor Barrier Compound: Water-based, fire-resistive composition.

1. Water Vapor Permeance: 0.08 perm maximum.
2. Temperature Range: Minus 20 to 180 degrees F.

B. Weatherproof Sealant: Flexible-elastomer-based, vapor-barrier sealant designed to seal metal joints.

1. Water Vapor Permeance: 0.02 perm maximum.
2. Temperature Range: Minus 50 to 250 degrees F.
3. Color: Aluminum.

PART 3 - EXECUTION

3.1 PREPARATION

A. Surface Preparation: Clean, dry, and remove foreign materials such as rust, scale and dirt.

B. Mix insulating cements with clean potable water. Mix insulating cements contacting stainless-steel surfaces with demineralized water.

1. Follow cement manufacturer's printed instructions for mixing and portions.

3.2 INSTALLATION, GENERAL

A. Refer to schedules at the end of this section for materials, forms, jackets and thicknesses required for each mechanical system.

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

C. Install vapor barriers on insulated pipes, ducts and equipment having surface operating temperatures below 60 degrees F.

D. Apply insulation material, accessories and finishes according to the manufacturer's printed instructions.

E. Install insulation with smooth, straight and even surfaces.

F. Seal joints and seams to maintain vapor barrier on insulation requiring a vapor barrier.

G. Seal penetrations for hangers, supports, anchors and other projections in insulation requiring a vapor barrier.

H. Seal Ends: Except for flexible elastomeric insulation, taper ends at 45 degree angle and seal with lagging adhesive. Cut ends of flexible elastomeric cellular insulation square and seal with adhesive.

I. Apply adhesives and coatings at manufacturer's recommended coverage-per-gallon rate.

J. Keep insulation materials dry during application and finishing.

K. Items Not Insulated: Unless otherwise indicated, do not apply insulation to the following systems, materials and equipment:

1. Fibrous glass ducts
2. Metal ducts with duct liner
3. Factory-insulated flexible ducts
4. Factory-insulated plenums, casings, terminal boxes and filter boxes and sections
5. Flexible connectors for ducts and pipes
6. Vibration control devices
7. Testing laboratory labels and stamps
8. Nameplates and data plates
9. Access panels and doors in air distribution systems
10. Fire protection piping systems
11. Sanitary drainage and vent piping
12. Drainage piping located in crawl spaces, unless indicated otherwise
13. Below grade cold water piping
14. Chrome-plated pipes and fittings except for plumbing fixtures for the disabled
15. Piping specialties including air chambers, unions, strainers, check valves, plug valves and flow regulators

3.3 PIPE INSULATION INSTALLATION, GENERAL

A. Tightly butt longitudinal seams and end joints. Bond with adhesive.

B. Stagger joints on double layers of insulation.

C. Apply insulation continuously over fittings, valves and specialties except as otherwise indicated.

D. Apply insulation with a minimum number of joints.

E. Apply insulation with integral jackets as follows:

1. Pull jacket tight and smooth.
2. Cover circumferential joints with butt strips, at least 3 inches wide, and of same material as insulation jacket. Secure with adhesive and outward clinching staples along both edges of butt strip and space 4 inches on center.
3. Longitudinal Seams: Overlap seams at least 1½ inches. Apply insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 4 inches on center.

    a. Exception: Do not staple longitudinal lamps on insulation applied to piping systems with surface temperatures at or below 35 degrees F.

4. Vapor Barrier Coatings: Where vapor barriers are indicated, apply on seams and joints, over staples, and at ends butt to flanges, unions, valves and fittings.
5. At penetrations in jackets for thermometers and pressure gauges, fill and seal voids with vapor barrier coating.
6. Repair damaged insulation jackets, except metal jackets, by applying jacket material around damaged jacket. Adhere, staple, and seal. Extend patch at least 2 inches in both directions beyond damaged insulation jacket and around the entire circumference of the pipe.

F. Roof Penetrations: Apply insulation for interior applications to a point even with the top of the roof flashing. Seal with vapor barrier coating. Apply insulation for exterior applications butted tightly to interior insulation ends. Extend metal jacket for exterior insulation outside roof flashing at least 2 inches below top of roof flashing. Seal metal jacket to roof flashing with vapor barrier coating.

G. Interior Walls and Partitions Penetrations: Apply insulation continuously through walls and partitions, except fire-rated walls and partitions. Apply an aluminum jacket with factory-applied moisture barrier over insulation. Extend 2 inches from both surfaces of wall or partition. Secure aluminum jacket with metal bands at both ends. Seal ends of jacket with vapor barrier coating. Seal around penetration with joint sealer. Refer to Division 7 Section, Joint Sealants.

H. Fire-Rated Walls and Partitions Penetrations: Terminate insulation at penetrations through fire-rated walls and partitions. Seal insulation ends with vapor barrier coating. Seal around penetration with fire stopping or fire-resistant joint sealer. Refer to Division 7 for fire stopping and fire-resistant joint sealers.

I. Floor Penetrations: Terminate insulation underside of floor assembly and at floor support at top of floor.

J. Flanges, Fittings and Valves-Interior Exposed and Concealed: Coat pipe insulation ends with vapor barrier coating. Apply pre-molded, precut or field-fabricated segments of insulation around flanges, unions, valves and fittings. Make joints tight. Bond with adhesive.

1. Use same material and thickness as adjacent pipe insulation.
2. Overlap nesting insulation by 2 inches or 1-pipe diameter, whichever is greater.
3. Apply materials with adhesive, fill voids with mineral fiber insulating cement. Secure with wire or tape.
4. Insulate elbows and tees smaller than 3 inches pipe size with pre-molded insulation.

5. Insulate elbows and tees 3 inches and larger with pre-molded insulation or insulation material segments. Use at least three segments for each elbow.
6. Cover insulation, except for metal jacketed insulation, with PVC fitting covers and seal circumferential joints with butt strips.

K. Hangers and Anchors: Apply insulation continuously through hangers and around anchor attachments. Install saddles, shields and inserts as specified in Division 15 Section, Supports and Anchors. For cold surface piping, extend insulation on anchor legs a minimum of 12 inches and taper and seal insulation ends.

1. Inserts and Shields: Cover hanger inserts and shields with jacket material matching adjacent pipe insulation.

3.4 BELOW GROUND PIPE INSULATION INSTALLATION

A. General: The following are additional requirements for insulation applied to piping installed below ground.

B. Coat bare surfaces of insulation materials with insulating cement of type recommended by insulation manufacturer. Apply enough cement to fill surface cells. Do not use adhesives for this coating.

C. Secure insulation with a minimum of two stainless-steel bands for each section of insulation.

D. Secure insulation with a minimum of two reinforced tape bands for each section of insulation.

E. Terminate insulation at anchor blocks.

F. Apply insulation continuously through sleeves and manholes, except as specified above for exterior wall penetrations.

G. Finishing: Apply three coats of asphaltic mastic to a finish thickness of 3/16 inch over insulation materials. Apply 10x10 mesh glass cloth between coats. Overlap edges of glass cloth by 2 inches.

3.5 GLASS FIBER PIPE INSULATION INSTALLATION

A. Bond insulation to pipe with lagging adhesive.

B. Seal exposed ends with lagging adhesive.

C. Seal seams and joints with vapor barrier compound.

3.6 CALCIUM SILICATE PIPE INSULATION INSTALLATION

A. Secure insulation with stainless-steel bands spaced at 12 inch intervals.

B. Apply two-layer insulation with joints tightly butted and staggered at least 3 inches. Secure inner layer with 16-gauge soft-annealed stainless-steel wire spaced at 12 inch intervals. Secure outer layer with stainless-steel bands at 12 inch intervals.

C. Finishing: Apply a skim coat of mineral fiber, hydraulic-setting cement to surface of installed insulation. When dry, apply flood coat of lagging adhesive and press on one layer of glass cloth or glass tape. Overlap edges at least 1 inch. Apply finish coat of lagging adhesive over glass cloth or tape. Thin finish coat to achieve smooth finish.

3.7 EQUIPMENT INSULATION INSTALLATION, GENERAL

A. Install board and block materials with a minimum dimension of 12-inches and a maximum dimension of 48-inches.

B. Groove and score insulation materials as required to fit as closely as possible to the equipment and to fit contours of equipment. Stagger end joints.

C. Insulation Thicknesses Greater than 2 inches: Install insulation in multiple layers with staggered joints.

D. Bevel insulation edges for cylindrical surfaces for tight joint.

E. Secure sections of insulation in place with wire or bands spaced at 9 inch centers, except for flexible elastomeric cellular insulation.

F. Protect exposed corners with corner angles under wires and bands.

G. Manholes, Handholes and Information Plates: Bevel and seal insulation ends around manholes, handholes, ASME stamps and nameplates.

3.8 DUCT INSULATION

A. Install block and board insulation as follows:

1. Adhesive and Band Attachment: Secure block and board insulation tight and smooth with at least 50 percent coverage of adhesive. Install bands spaced 12 inches apart. Protect insulation under bands and at exterior corners with metal corner angles. Fill joints, seams and chipped edges with vapor barrier compound.
2. Speed Washers Attachment: Secure insulation tight and smooth with speed washers and welded pins. Space anchor pins 18 inches apart each way and 3 inches from insulation joints. Apply vapor barrier coating compound to insulation in contact, open joints, breaks, punctures and voids in insulation.

B. Blanket Insulation: Install tight and smooth. Secure to ducts having long sides or diameters as follows:

1. Smaller than 24 inches: Bonding adhesive applied in 6 inch wide transverse strips on 12 inch centers.
2. Twenty-four inches and Larger: Anchor pins spaced 12 inches apart each way.
   Apply bonding adhesive to prevent sagging of the insulation.
3. Overlap joints 3 inches.
4. Seal joints, breaks and punctures with vapor barrier compound.

3.9 JACKETS

A. Foil and Paper Jackets (FP): Install jackets drawn tight. Install lap or butt strips at joints with material same as jacket. Secured with adhesive. Install jackets with 1½ inch laps at longitudinal joints and 3 inch wide butt strips at end joints.

1. Seal openings, punctures, and breaks in vapor barrier jackets and exposed with vapor barrier compound.

3.10 APPLICATIONS

A. General: Materials and thicknesses are specified in schedules at the end of this section.

B. Interior Piping Systems: Unless otherwise indicated, insulate the following piping systems:

1. Domestic cold water
2. Storm water. Insulate only roof drain bodies and horizontal rainwater leaders of storm water piping.
3. Domestic hot water
4. Re-circulated hot water
5. Sanitary drains for fixtures accessible to the disabled
6. Heating hot water supply & return
7. Snow melt supply & return
8. Cooling Coil Condensate
9. Chilled water supply and return
10. Steam
11. Steam Condensate
12. Pumped Steam Condensate
13. Boiler Feed piping

C. Duct Systems: Unless otherwise indicated, insulate the following:

1. Interior outside air ductwork
2. Interior concealed supply and return ductwork
3. Interior exposed supply and return ductwork
3. Sound absorbers
4. Relief air ductwork
5. Outside air ductwork.

3.11 PIPING INSULATION SCHEDULES

A. General: Abbreviations used in the following schedules include:

1. Field-Applied Jackets: K - Foil and Paper.
2. Piping Sizes: NPS - Nominal Pipe Size

B.

INTERIOR COOLING COIL CONDENSATE

PIPE SIZES (NPS)	MATERIALS	THICKNESS IN INCHES	VAPOR BARRIER REQ'D	FIELD-APPLIED JACKET
ALL	GLASS FIBER	1/2	YES	NONE

INTERIOR HYDRONIC (100 TO 250º F)
EXPOSED AND CONCEALED

PIPE SIZES (NPS)	MATERIALS	THICKNESS IN INCHES	VAPOR BARRIER REQ'D	FIELD-APPLIED JACKET
1/2 TO 2	GLASS FIBER	1	NO	NONE
3 TO 10	GLASS FIBER	1½	NO	NONE

INTERIOR HYDRONIC (35° - 55°F)

PIPE SIZES (NPS)	MATERIALS	THICKNESS IN INCHES	VAPOR BARRIER REQ'D	FIELD-APPLIED JACKET
ALL	GLASS FIBER	1	YES	NONE

EXTERIOR HYDRONIC (35° - 55°F)

PIPE SIZES (NPS)	MATERIALS	THICKNESS IN INCHES	VAPOR BARRIER REQ'D	FIELD-APPLIED JACKET
ALL	POLYSTYRENE	1½	YES	ALUMINUM

INTERIOR REFRIGERANT SUCTION
(35 TO 100°F) EXPOSED AND CONCEALED

PIPE SIZES (NPS)	MATERIALS	THICKNESS IN INCHES	VAPOR BARRIER REQ'D	FIELD-APPLIED JACKET
ALL	FLEXIBLE ELAST.	3/4	YES	NONE

EXTERIOR REFRIGERANT SUCTION (35 – 100°) EXPOSED AND CONCEALED

PIPE SIZES (NPS)	MATERIALS	THICKNESS IN INCHES	VAPOR BARRIER REQ'D	FIELD-APPLIED JACKET
ALL	GLASS FIBER	3/4	YES	PVC

STEAM AND CONDENSATE, BOILER FEED, PUMPED CONDENSATE (450° AND LOWER) EXPOSED AND CONCEALED

PIPE SIZES (NPS)	MATERIALS	THICKNESS IN INCHES	VAPOR BARRIER REQ'D	FIELD-APPLIED JACKET
½ TO 4	GLASS FIBER	1	NO	NONE
ABOVE 4	GLASS FIBER	1½	NO	NONE

3.12 DUCT SYSTEMS INSULATION SCHEDULE

INTERIOR CONCEALED HVAC SUPPLY DUCT AND PLENUMS

MATERIAL	FORM	THICKNESS IN INCHES	VAPOR BARRIER REQ'D	FIELD-PPLIED JACKET
GLASS FIBER FIBERGLASS	BLANKET	1-1/2	YES	NONE

INTERIOR EXPOSED HVAC SUPPLY AND RETURN DUCTS AND PLENUMS IN MECHANICAL ROOMS AND UNCONDITIONED SPACES.

MATERIAL	THICKNESS FORM	VAPOR IN INCHES	FIELD-BARRIER REQ'D	APPLIED JACKET
GLASS FIBER FIBERGLASS	BOARD-RECT.	1-1/2	YES	NONE

INTERIOR EXPOSED OUTSIDE AIR DUCTS, RELIEF AIR DUCTS, AND PLENUMS

MATERIAL	FORM	THICKNESS IN INCHES	VAPOR BARRIER REQ'D	FIELD-APPLIED JACKET
FIBERGLASS	BLANKET	2	YES	NONE

INTERIOR CONCEALED OUTSIDE AIR DUCTS, RELIEF AIR DUCTS, AND PLENUMS

MATERIAL	FORM	THICKNESS IN INCHES	VAPOR BARRIER REQ'D	FIELD-APPLIED JACKET
FIBERGLASS	BLANKET	2	YES	NONE

* EXTERNAL INSULATION NOT REQUIRED FOR EXPOSED DUCTS LOCATED IN CONDITIONED SPACES.

3.13 STEAM BOILER FEED SYSTEM, STEAM BOILER BLOWDOWN TANK, STEAM CONDENSATE TANK, FLASH TANK, BOILER EXPANSION TANK, AND AIR SEPARATOR

A. Cover the entire surface (except handholes and nameplates) with a 1½ inch thick blanket of high temperature fiberglass insulation with a density of 6.00 lb./cu. ft. Wire insulation in place prior to covering the glass cloth using fire retardant adhesive. Apply a second coat of adhesive to provide a smooth surface for painting.

3.14 CHILLER EXPANSION TANKS, BUFFER TANK AND AIR SEPARATORS

A. Cover the entire surface (except nameplates) with two layers of ¾-inch flexible elastomeric thermal insulation. Use manufacturer’s recommended adhesive. Seal longitudinal seams and end joints.

3.15 CHILLED WATER PUMPS

A. Cover the entire surface (pump housing only) with two layers of ¾-inch flexible elastomeric thermal insulation. Use manufacturer’s recommended adhesive. Seal longitudinal seams and end joints.

3.16 BOILER BREACHING

A. Insulate the entire breaching (including all flanges) from the unit with 1½ inch thick block (or flexible board) type calcium silicate insulation with a .016-inch aluminum jacket. Double walled broiler breaching does not require insulation.

END OF SECTION

SECTION 15110 - VALVES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes general duty valves common to several mechanical piping systems.

B. Related Sections: The following Sections contain requirements that relate to this Section:

1. Special purpose valves are specified in Division 15 piping system Sections.

1.2 SUBMITTALS

A. Product Data for each valve type. Include body material, valve design, pressure and temperature classification, end connection details, seating materials, trim material and arrangement, dimensions and required clearances, and installation instructions. Include list indicating valve and its application.

B. Maintenance data for valves to include will be in the operation and maintenance manual specified in Division 1. Include detailed manufacturer's instructions on adjusting, servicing, disassembling, and repairing.

1.3 QUALITY ASSURANCE

A. ASME Compliance: Comply with ASME B31.9 for building services piping and ASME B31.1 for power piping.

B. MSS Compliance: Comply with the various MSS Standard Practice documents referenced.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

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

B. Use the following precautions during storage:

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

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

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Gate Valves:

a. Apollo
b. Crane Company; Valves and Fitting Division.
c. Hammond Valve Corporation
d. Milwaukee Valve Corporation
e. NIBCO Inc.
f. Powell Valve Company

2. Ball Valves:

a. Apollo
b. Conbraco Ind., Inc. Apollo Div
c. Hammond Valve Corporation
d. Jamesbury
e. Milwaukee
f. Rube
g. Worchester
h. Watts

3. Plug Valves: (Non-Lubricated Eccentric Type)

a. Apollo
b. DeZurik
c. Keystone Valve Company
d. Homestead

4. Globe Valves:

a. Apollo
b. Crane Company; Valves and Fitting Division.
c. Hammond Valve Corporation
d. Milwaukee Valve Corporation
e. NIBCO Inc.
f. Powell Valve Company

5. Butterfly Valves: (Resilient Seated)

a. Apollo
b. Center Line, (Crane Company)
c. DeZurik

d. Tyco/Grinnell Corporation
e. Hammond Valve Corporation
f. Keystone
g. Milwaukee Valve Corporation

6. Butterfly Valves (High Performance)

a. Apollo
b. Jamesbury Series 815 (150 Cl) or Series 830 (300 Cl)
c. DeZurik BHP 150Cl or 300Cl
d. Keystone Series 362 (150 Cl) or 372 (300 Cl)

7. Check Valves - Swing Type

a. Crane Company, Valves and Fitting Division
b. Hammond
c. Milwaukee
d. NIBCO, Inc
e. Powell Valve Company

8. Check Valves - Wafer Silent Type

a. Cla-Val Company
b. Gulf Valve Company
c. Hammond Valve Company
d. Key stone
e Metraflex
f. Val-Matic Valve & Mfg. Co.

2.2 BASIC, COMMON FEATURES

A. Design: Rising stem or rising outside screw and yoke stems, except as specified below.

1. Non-rising stem valves may be used only where headroom prevents full extension of rising stems.

B. Pressure and Temperature Ratings: As indicated in the "Application Schedule" of Part 3 of this Section and as required to suit system pressures and temperatures.

C. Sizes: Same size as upstream pipe, unless otherwise indicated.

D. Operators: Use specified operators and handwheels, except provide the following special operator features:

1. Handwheels: For valves other than quarter turn.
2. Lever Handles: For quarter-turn valves 6 inches and smaller, except for plug valves, which shall have square heads. Furnish Owner with 1 wrench for every 1 0 plug valves.
3. Chain-Wheel Operators: For valves 4 inches and larger, installed 96 inches or higher above finished floor elevation.
4. Gear-Drive Operators: For quarter-turn valves 8 inches and larger.

E. Extended Stems: Where insulation is indicated or specified, provide extended stems arranged to receive insulation.

F. Bypass and Drain Connections: Comply with MSS SP-45 bypass and drain connections.

G. Threads: ASME Bl.20.1.

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

I. Solder Joint: ASME Bl 6.18.

1. Caution: Where soldered end connections are used, use solder having a melting point below 840 deg F for gate, globe, and check valves; below 421 deg for ball valves.

2.3 GATE VALVES

A. Gate Valves, 2 1/2 Inches and Larger: MSS SP-70, Class 125, 200-psi CWP, ASTM A 126 cast-iron body and bonnet, solid cast-iron wedge, brass-alloy stem, outside screw and yoke, no asbestos packing with 2-piece packing gland assembly, flanged end connections; and with cast-iron handwheel.

2.4 BALL VALVES

A. Ball Valves, 2 inches and Smaller: MSS SP-1 1 0, Class 150, 600-psi CWP, ASTM B 584 bronze body and bonnet, 2-piece construction; chrome-plated brass ball, standard port, blowout proof stem; Teflon seats and seals; threaded or soldered end connections. Valves shall have lever handles and shall have stem extensions for insulation where required.

B. Ball Valves 2-1/2 inches and Larger: 150 PSI WP, carbon steel Body, stainless steel ball, reinforced Teflon seats and seals; standard bore with flanged connections, Valves 2 ½ inches through 4 inches shall have lever handles and valves 6 inches and larger to have gear operators

2.5 PLUG VALVES (Non-Lubricated Eccentric Type)

A. Plug Valves: MSS SP-78, 175-psi CWP, ASTM A 126 cast-iron body and bonnet, cast-iron plug, Buna N or Viton plug facing, Teflon packing, flanged or grooved end connections.

B. Valves through 4 inches shall have square heads and one wrench per valve. Valves 6 inches and larger shall be gear operated.

2.6 GLOBE VALVES

A. Globe Valves, 2 Inches and Smaller: MSS SP-80; Class 125, 200-psi CWP, or Class 150, 300-psi CWP; ASTM B 62 cast-bronze body and screwed bonnet, rubber, bronze, or Teflon disc, silicon bronze-alloy stem, non asbestos packing with bronze nut, threaded or soldered end connections; and with aluminum or malleable-iron handwheel.

B. Globe Valves, 2 1/2 Inches and Larger: MSS SP-85, Class 125, 200-psi CWP, ASTM A 126 cast-iron body and bolted bonnet with bronze fittings renewable bronze seat and disc, brass-alloy stem, outside screw and yoke, non asbestos packing with cast-iron follower, flanged end connections; and with cast iron handwheel.

2.7 BUTTERFLY VALVES (Resilient Seated)

A. Butterfly Valves: MSS SP-67, 200-psi CWP, 150-psi pressure differential, ASTM A 126 cast-iron body, wafer or lug style, extended neck, stainless-steel stem, EPDM or Buna N seats and stem seals, discs shall be aluminum bronze or stainless steel. For dead end service valves shall be lug type and not be derated by the manufacturer. Valves 2 inches thru 4 inches shall have 10 position lever handles and valves 6 inches and larger gear operators with position indicators.

2.8 BUTTERFLY VALVES (High Performance)

A Butterfly, 2 1/2 inch and larger: ANSI 150 or 300 (as required) carbon steel body, wafer or lug type as designated, stainless steel disc, filled Teflon seats and seals. Valves shall be of the double off set shaft and disc design. Valves 2-1/2 inches thru 4 inches shall have lever handles and valves 6 inches and larger gear operators.

2.9 CHECK VALVES

A. Swing Check Valves, 2-1/2 Inches and Smaller: MSS SP-80; Class 125, 200psi CWP, or Class 150, 300-psi CWP; horizontal swing, Y-pattern, ASTM B 62 cast-bronze body, bronze disc with composition seat, threaded or soldered end connections:

B. Swing Check Valves, 3 Inches and Larger: MSS SP-71, Class 125, 200-psi CWP, ASTM A 126 cast-iron body and bolted cap, horizontal-swing bronze disc, flanged end connections.

C. Wafer Check Valves: Class 125, 200-psi CWP, ASTM A 126 cast-iron body, aluminum bronze disc/plates, stainless-steel pins and springs, Buna N or EPDM seals, installed between flanges.

D. Lift Check Valves: Class 125, ASTM B 62 bronze body and cap (main components), horizontal or vertical pattern, lift-type, bronze disc or Buna N rubber disc with stainless steel holder threaded or soldered end connections.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine piping system for compliance with requirements for installation tolerances and other conditions affecting performance of valves. Do not proceed with installation until unsatisfactory conditions have been corrected.

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

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

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

E. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Check gasket material for proper size, material composition suitable for service, and freedom from defects and damage.

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

3.2 INSTALLATION

A. Install valves as indicated, according to manufacturer's written instructions.

B. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate the general arrangement of piping, fittings, and specialties.

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

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

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

F. Install valves in a position to allow full stem movement.

G. For chain-wheel operators, extend chains to 60 inches above finished floor elevation.

H. Installation of Check Valves: Install for proper direction of flow as follows:

1. Swing Check Valves: Horizontal position with hinge pin level.
2. Wafer Check Valves: Horizontal or vertical position, between flanges.
3. Lift Check Valve: With stem upright and plumb.

3.3 SOLDERED CONNECTIONS

A. Cut tube square and to exact lengths.

B. Clean end of tube to depth of valve socket with steel wool, sand cloth, or a steel wire brush to a bright finish. Clean valve socket.

C. Apply proper soldering flux in an even coat to inside of valve socket and outside of tube.

D. Open gate and globe valves to fully open position.

E. Remove the cap and disc holder of swing check valves having composition discs.

F. Insert tube into valve socket, making sure the end rests against the shoulder inside valve. Rotate tube or valve slightly to ensure even distribution of the flux.

G. Apply heat evenly to outside of valve around joint until solder melts on contact. Feed solder until it completely fills the joint around tube. Avoid hot spots or overheating valve. Once the solder starts cooling, remove excess amounts around the joint with a cloth or brush.

3.4 THREADED CONNECTIONS

A. Note the 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.

B. Align threads at point of assembly.

C. Apply appropriate tape or thread compound to the external pipe threads, except where dry seal threading is specified.

D. Assemble joint, wrench tight. Wrench on valve shall be on the valve end into which the pipe is being threaded.

3.5 FLANGED CONNECTIONS

A. Align flange surfaces parallel.

B. 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.

C. For dead-end service, butterfly valves require lug type bodies. Butterfly valves shall not be derated by the manufacturer.

3.6 VALVE END SELECTION

A. Select valves with the following ends or types of pipe/tube connections:

1. Copper Tube Size, 2-1/2 Inches and Smaller: Solder ends, except provide threaded ends for heating hot water and low-pressure steam service.
2. Steel Pipe Sizes, 2-1/2 Inches and Smaller: Threaded or grooved end.
3. Steel Pipe Sizes, 3 Inches and Larger: Grooved end or flanged.

3.7 APPLICATION SCHEDULE

A. General Application: Use gate, ball, and butterfly valves for shutoff duty; globe, ball, and butterfly for throttling duty. Refer to piping system Specification Sections for specific valve applications and arrangements.

B. Domestic Water Systems: Use the following valve types:

1. Ball Valves: Class 150, 600-psi CWP, bronze, with stem extension.
2. Plug Valves: BUNA-N faced plug; BUNA N packing.
3. Globe Valves: Class 125, bronze or cast-iron body to suit piping system, and bronze or teflon disc.
4. Bronze Swing Check: Class 125, with rubber seat.
5. Check Valves: Class 125, swing or wafer type as indicated.

C. Heating Water Systems: Use the following valve types:

1. Gate Valves: Class 150, bronze or cast-iron body to suit piping system.
2. Ball Valves: Class 150, 600-psi CWP, bronze with stem extension and memory stop.
3. Plug Valves: Eccentric type; EPDM or BUNA-N plug facing
4. Globe Valves: Class 150, bronze or cast-iron body to suit piping system, and bronze disc.
5. Butterfly Valves: Aluminum bronze disc, EPDM or Buna N sleeve and stem seals.
6. Bronze Swing Check: Class 150, with composition seat.
7. Check Valves: Iron swing, wafer, or lift type, as indicated. Swing check shall be Class 150 with bronze seat ring.

D. Low-Pressure Steam and Condensate Return Systems: Use the following valve types:

1. Gate Valves: Class 150, bronze body; or Class 125, cast-iron body.
2. Ball Valves: C. I. Body w/ C.I. Teflon Fused Ball, handles w/stem extension.
3. Globe Valves: Class 150, bronze body with teflon disc; or Class 125, cast-iron body.
4. Check Valves: Class 150, bronze body swing check with composition seat; Class 150, cast-iron body swing check with bronze seat ring; or Class 125, cast iron body wafer check.

E. Chilled-Water Systems: Use the following valve types:

1. Gate Valves: Class 150, bronze body; or Class 125, cast-iron body.
2. Ball Valves: Class 150, 600-psi CWP, with stem extension and memory stop.
3. Plug Valves: Buna N plug facing and packing.
4. Globe Valves: Class 125, bronze body with bronze or teflon disc; or Class 125, cast-iron body.
5. Butterfly Valves: Aluminum bronze disc; EPDM sleeve and stem seals.
6. Check Valves: Class 125, bronze body swing check with rubber seat; Class 125, cast-iron body swing check; Class 125, cast-iron body wafer check; or Class 125, cast-iron body lift check.

F. Condenser Water Systems: Use the following valve types:

1. Gate Valves: Class 125, bronze body; or Class 125, cast-iron body.
2. Ball Valves: Class 150, 600-psi CWP, with memory stop.
3. Plug Valves: Buna N plug facing and packing.
4. Globe Valves: Class 125, bronze body with bronze or teflon disc; or Class 125, cast-iron body.
5. Butterfly Valves: Aluminum bronze disc; EPDM sleeve and stem seals.
6. Check Valves: Class 125, bronze body swing check with rubber seat; Class 125, cast-iron body swing check; Class 125, cast-iron body wafer check; or Class 125, cast-iron body lift check.

G. High-Pressure Steam Piping: Use the following valve types:

1. Angle Valves, NPS 2 and Smaller: Type 2, Class 200, bronze.
2. Angle Valves, NPS 2½ and Larger: Type II, Class 250, cast iron.
3. Ball Valves, NPS 2 and Smaller: Three-piece, 400-psig CWP rating, copper alloy.
4. Ball Valves, NPS 2½ and Larger: Class 300, ferrous alloy.
5. High-Pressure Butterfly Valves, NPS 3 and Larger: Single-flange, Class 300.

6. Swing Check Valves, NPS 2 and Smaller: Type 4, Class 200, bronze.
7. Swing Check Valves, NPS 2½ and Larger: Type II, Class 250, gray iron.
8. Gate Valves, NPS 2 and Smaller: Type 3, Class 200, bronze.
9. Gate Valves, NPS 2½ and Larger: Type I, Class 250, OS&Y, bronze-mounted cast iron.
10. Globe Valves, NPS 2 and Smaller: Type 1, Class 200, bronze.
11. Globe Valves, NPS 2½ and Larger: Type 1, Class 250, bronze-mounted cast iron.

H. Steam Condensate Piping: Use the following valve types:

1. Ball Valves, NPS 2 and Smaller: Three-piece, 400-psig CWP rating, copper alloy.
2. Ball Valves, NPS 2½ and Larger: Class 300, ferrous alloy.
3. High-Pressure Butterfly Valves, NPS 3 and Larger: Flangeless, Class 300.
4. Swing Check Valves, NPS 2 and Smaller: Type 4, Class 200, bronze.
5. Swing Check Valves, NPS 2½ and Larger: Type II, Class 250, gray iron.
6. Spring-Loaded, Lift-Disc Check Valves, NPS 2 and Smaller: Type IV, Class 200.
7. Spring-Loaded, Lift-Disc Check Valves, NPS 2½ and Larger: Type III, Class 250, cast iron.
8. Gate Valves, NPS 2 and Smaller: Type 3, Class 200, bronze.
9. Gate Valves, NPS 2½ and Larger: Type I, Class 250, OS&Y, bronze-mounted cast iron.
10. Globe Valves, NPS 2 and Smaller: Type 2, Class 200 bronze.
11. Globe Valves, NPS 2½ and Larger: Type I, Class 250, bronze-mounted cast iron.

3.8 VALVE INSTALLATION

A. Piping installation requirements are specified in other Division 15 sections. Drawings indicate general arrangement of piping, fittings, and specialties.

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

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

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

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

F. Install chainwheel operators on valves NPS 4 and larger and more than 96 inches above floor. Extend chains to 60 inches above finished floor elevation.

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

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

3.9 ADJUSTING

A. Adjust or replace packing after piping systems have been tested and put into service, but before final adjusting and balancing. Replace valves if leak persists.

END OF SECTION

SECTION 15121 - PIPE EXPANSION JOINTS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes pipe expansion joints, guides and anchors for mechanical piping systems.

1.2 PERFORMANCE REQUIREMENTS

A. Compatibility: Provide pipe expansion joints, pipe alignment guides, and pipe anchors suitable for piping system fluids, materials, working pressures and temperatures.

B. Fabricate and install expansion and anchor system capable of sustaining forces generated by gravity, thermal movement, and seismic events.

C. Design and obtain approval from authority with jurisdiction, seismic restraints for pipe expansion joints and pipe anchor system.

1.3 SUBMITTALS

A. General: Submit the following according to the Conditions of the Contract and Division 1 Specification Sections.

B. Product data for each type of pipe expansion joint and pipe alignment guide specified.

C. Pipe expansion joint schedule showing manufacturer's figure number, size, location, and features for each required expansion joint.

D. Assembly-type shop drawings for each type of pipe expansion joint, pipe alignment guide, and anchor, indicating dimensions, weights, required clearances, and methods of component assembly.

E. Maintenance data for each type pipe expansion joint specified to include the Operating and Maintenance Manuals specified in the Division 1 Section, Project Closeout.

1.4 QUALITY ASSURANCE

A. Qualify welding processes and welding operators according to ASME, Boiler and Pressure Vessel Code, Section IX, Welding and Brazing Qualifications.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Metal-Bellow, Packless-Type Pipe Expansion Joints:
   Adsco Manufacturing Corporation
   Keflex, Inc.
   Metraflex Company

Senior Flexonics Inc., Expansion Joint Division

2. Expansion-Compensator, Packless-Type Expansion Joints:
   Adsco Manufacturing Corporation
   Keflex, Inc.
   Metraflex Company
   Senior Flexonics Inc., Expansion Joint Division
3. Rubber-Sphere, Packless-Type Pipe Expansion Joints:
   General Rubber Corporation
   Keflex, Inc.
   Mercer Rubber Company
   Metraflex Company
   Senior Flexonics Inc., Expansion Joint Division
   Vibration Mountings & Controls, Inc.
4. Slip-Type Pipe Expansion Joints:
   Adsco Manufacturing Corporation
   Advanced Thermal Systems, Inc.
5. Coupling, Grooved-Piping-Type Pipe Expansion Joints:
   Grinnell Corporation, Pipe Supports Division
   Gustin-Bacon Div., Tyler Pipe Subsid., Tyler Corp.
   Stockham Valves & Fittings, Inc.
   Victaulic Company of America
6. Slip-Joint, Grooved-Piping-Type Pipe Expansion Joints:
   Victaulic Company of America
7. Pipe Alignment Guides:
   Adsco Manufacturing Corporation
   Advanced Thermal Systems, Inc.
   B-Line Systems, Inc.
   Grinnell Corp., Pipe Supports Division
   Hyspan Precision Products, Inc.
   Keflex, Inc.
   Metraflex Company

2.2 PIPE EXPANSION JOINTS, GENERAL

A. Capability: Absorb 200 percent of maximum piping expansion between anchors.

2.3 PACKLESS-TYPE PIPE EXPANSION JOINTS

A. Metal-Bellows Packless-Type Pipe Expansion Joints: Pressure rated for 175 psig minimum; conform to the standards of Expansion Joint Manufacturers Association, Inc. (EJMA); with end fittings and external tie rods for limited maximum travel. Features include the following:

   1. Copper Piping Systems: Two-ply phosphor-bronze bellows and brass shrouds.
   2. Steel Piping Systems: Two-ply stainless-steel bellows and carbon-steel shrouds.

B. Expansion-Compensator Packless-Type Pipe Expansion Joints: Pressure rated for 60 psig minimum for low-pressure systems and for 175 psig minimum for high-pressure systems. Include two-ply phosphor bronze bellows, brass shrouds, and end fittings for copper piping systems and two-ply stainless steel bellows, carbon-steel shrouds, and end fittings for steel piping systems.
Include internal guides, anti-torque device, and removable end clip for proper positioning.

C. Rubber-Sphere Packless-Type Expansion Joints: Single-sphere type, fabric-reinforced butyl rubber with full-faced integral flanges, external control rods and internal reinforcing. Include steel retaining rings drilled to match flange bolt holes over entire surface of flanges. Pressure rating is 175 psig minimum at 240 degrees F minimum.

D. Rubber-Sphere Packless-Type Pipe Expansion Joints: Double-sphere type, fabric-reinforced butyl rubber with full-faced integral flanges, external control rods, and internal reinforcing. Include steel retaining rings drilled to match flange bolt holes over entire surface of flanges. Pressure rating is 175 psig minimum at 240 degrees F minimum.

2.4 SLIP-TYPE PIPE EXPANSION JOINTS

A. Carbon-steel packing-type expansion joint designed for repacking under pressure. Include limit stops, flanged or weld ends to match piping system, and drip connections where used for steam piping systems.

1. Joint Packing: Asbestos-free polytetrafluoroethylene (PTFE) compound.
2. Pressure Rating: 250 psig minimum at 400 degrees F minimum.

2.5 GROOVED-PIPING-TYPE PIPE EXPANSION JOINTS

A. Coupling: ASTM A 53, cut-grooved, short, steel-pipe nipples, and ductile-iron or malleable-iron shouldered couplings. Include removable ties to hold joint compressed or expanded during piping fabrication. Include suitable gasket materials for piping system.

B. Slip-Joint: ASTM A 53, steel-pipe body; polytetrafluoroethylene (PTFE), modified-polyphenylene-coated steel-pipe slide; and ductile-iron or malleable-iron housing. Include suitable gasket material for piping system.

2.6 PIPE ALIGNMENT GUIDES

A. Factory-fabricated cast semi-steel or heavy fabricated steel, consisting of bolted 2-section outer cylinder and base. Include 2-section guiding spider that bolts tightly to the pipe.

2.7 MISCELLANEOUS MATERIALS

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

B. Bolts and Nuts: ASME B18.10 or ASTM A 183, steel, hex-head, track bolts and nuts.

C. Washers: ASTM F 844, steel, plain, flat washers.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions under which pipe expansion joints, pipe alignment guides, and pipe anchors are to be installed. Do not proceed until unsatisfactory conditions have been corrected.

3.2 PIPE EXPANSION JOINT INSTALLATION

A. Install pipe expansion joints according to manufacturer's written instructions.

B. Align expansion joints to avoid end-loading and torsional stress.

3.3 FABRICATED-TYPE PIPE EXPANSION OF COMPENSATION INSTALLATION

A. Install pipe expansion loops cold-sprung in tension or compression as required to absorb 50 percent of total compression or tension that will be produced during anticipated change in temperature.

B. Connect risers to terminal units with at least four pipe fittings including tee in riser.

3.4 PIPE ALIGNMENT GUIDE INSTALLATION

A. Install pipe alignment guides on piping that adjoins pipe expansion joints and loops.

3.5 PIPE ANCHOR INSTALLATION

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

B. Fabricate and install anchors by welding steel shapes, plates, and bars to piping and to structure. Comply with ASME B31.9 and with AWS D1.1.

C. Construct concrete pipe anchors of poured-in-place concrete of dimensions indicated.

D. Where pipe expansion joints are indicated, install pipe anchors according to expansion unit manufacturer's written instructions to control movement to compensators.

E. Pipe Anchor Spacings: Where not otherwise indicated, install pipe anchors at ends of principal pipe runs, at intermediate points in pipe runs between expansion loops and bends. Preset anchors as required to accommodate both expansion and contractor of piping.

F. Use grout to form flat bearing surfaces for pipe expansion joints, pipe alignment guides, and pipe anchors that are installed on or in concrete.

3.6 PAINTING

A. Touching-Up: Clean field welds and abraded areas of shop paint and 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 by brush or spray to provide a minimum dry film thickness of 2.0 mils.

B. Touching Up: Cleaning and touchup painting of field welds, bolted connections and abraded areas of shop paint on miscellaneous metal is specified in Division 9 Section, Painting.

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

END OF SECTION

SECTION 15122 - METERS AND GAUGES

PART 1 – GENERAL

1.1 SUMMARY

A. This Section includes meters and gauges used in mechanical systems.

1.2 SUBMITTALS

A. General: Submit the following according to the Conditions of the Contract and Division 1 Specification Sections.

B. Product data for each type of meter, gauge, and fitting specified. Include scale range, ratings, and calibrated performance curves, certified where indicated. Submit a meter and gauge schedule showing manufacturer's figure number, scale range, location and accessories for each meter and gauge.

C. Product certificates signed by manufacturers of meters and gauges certifying accurateness under specified operating conditions and compliance with specified requirements.

D. Maintenance data to include in the Operating and Maintenance Manuals specified in Division 1 Section, Project Closeout.

1.3 QUALITY ASSURANCE

A. Comply with applicable portions of American Society of Mechanical Engineers (ASME) and Instrument Society of America (ISA) standards pertaining to construction and installation of meters and gauges.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Liquid-in-Glass Thermometers:
   Marsh Instrument Company
   Marshalltown Instruments, Inc.
   H.O. Trerice Company
   Weksler Instruments Corporation
2. Direct-Mounting Filled-System Dial Thermometers:
   Marsh Instrument
   H.O. Trerice Company
   Weksler Instruments Corp.
3. Remote-Reading Filled-System Dial Thermometers:
   Marsh Instrument
   H.O. Trerice Company
   Weksler Instruments Corporation

4. Bimetal Dial Thermometers:
   Marsh Instrument
   Marshalltown Instruments, Inc.
   H.O. Trerice Company
   Weksler Instruments Corporation
5. Insertion Dial Thermometers:
   H.O. Trerice Company
   Weksler Instruments Corporation
6. Pressure Gauges:
   Marsh Instrument
   Marshalltown Instruments, Inc.
   H.O. Trerice Company
   Weksler Instruments Corporation

2.2 THERMOMETERS, GENERAL

A. Scale Range: Temperature ranges for services listed as follows:

1. Domestic Hot Water: 30 to 240 degrees F, with two-degree scale.
2. Hot Water: 30 to 300 degrees F, with two-degree scale divisions.

B. Accuracy: Plus or minus one percent of range span or plus or minus one scale division to maximum of 1.5 percent of range span.

2.3 LIQUID-IN-GLASS THERMOMETERS

A. Description: ASTM E 1, liquid-in-glass thermometer.

B. Case: Die-cast and aluminum-finished in baked epoxy enamel, glass front, spring secured, nine inches long.

C. Adjustable Joint: Finished to match case, 180-degree adjustment in vertical plane, 360-degree adjustment in horizontal plane, with locking device.

D. Tube: Red-reading, organic liquid-filled instead of mercury-filled, with magnifying lens.

E. Scale: Satin-faced non-reflective aluminum with permanently etched markings.

F. Stem: Copper-plated, steel, aluminum or brass for a separable socket of length to suit installation.

2.4 DIRECT-MOUNTING FILLED-SYSTEM DIAL THERMOMETERS

A. Description: Vapor-actuated universal angle dial thermometer.

B. Case: Drawn steel or cast aluminum with 4-1/2-inch-diameter glass lens.

C. Adjustable Joint: Finish to match case, 180 degrees adjustment in vertical plane, 360 degrees adjustment in horizontal plane, with locking device.

D. Thermal Bulb: Copper with phosphor-bronze Bourdon pressure tube.

E. Movement: Brass, precision geared.

F. Scale: Progressive satin-faced non-reflective aluminum with permanently etched markings.

G. Stem: Copper-plated steel, aluminum, or brass for a separable socket of length to suit installation.

2.5 BIMETAL DIAL THERMOMETERS

A. Description: Direct-mounted universal-angle bimetal dial thermometer.

B. Case: Stainless steel with 5-inch-diameter glass lens.

C. Adjustable Joint: Finish to match case, 180 degree adjustment in vertical plane, 360 degree adjustment in horizontal plane, with locking device.

D. Element: Bimetal coil.

E. Scale: Satin-faced non-reflective-aluminum with permanently etched markings.

F. Stem: Stainless steel for separable socket, of length to suit installation.

2.6 INSERTION DIAL THERMOMETERS

A. Description: Bimetal dial thermometer.

B. Dial: One-inch diameter.

C. Case: Stainless steel.

D. Stem: Dustproof and leakproof 1/8 inch-diameter tapered-end stem with nominal length of 5 inches.

2.7 THERMOMETER WELLS

A. Description: Brass or stainless-steel thermometer well.

B. Pressure Rating: Not less than piping system design pressure.

C. Stem Length: To extend two inches into fluid.

2.8 PRESSURE GAUGES

A. Description: ASME B40.1, Grade A phosphor-bronze Bourdon-tube pressure gauge, with bottom connection.

B. Accuracy: Plus or minus one percent (1 percent) of range span.

C. Range: Conform to the following:

1. Vacuum: 30 inches Hg of vacuum to 15 psig of pressure.
2. Vacuum: 100 kPa of vacuum to 100 kPa of pressure.

3. Fluids Under Pressure: Two times operating pressure.

2.9 PRESSURE-GAUGE ACCESSORIES

A. Syphons: 1/4-inch straight coil of brass tubing with threads on each end.

B. Snubbers: 1/4-inch brass brushing with corrosion-resistant porous-metal disc of material suitable for system fluid and working pressure.

PART 3 - EXECUTION

3.1 METER AND GAUGE APPLICATIONS

A. General: Where indicated, install meters and gauges of types, sizes, capacities and with features indicated.

3.2 METER AND GAUGE INSTALLATION, GENERAL

A. Install meters, gauges and accessories according to manufacturer's written instructions for applications where used.

3.3 THERMOMETER INSTALLATION

A. Install thermometers and adjust vertical and titled positions.

B. Install in the following locations and elsewhere as indicated:

1. At inlet and outlet of each hydronic boiler and chiller.
2. At inlet and outlet of each hydronic coil in air-handling units and built-up central systems.
3. At inlet and outlet of each hydronic heat exchanger.

C. Remote-Reading Dial Thermometers: Install in control panels with tubing connecting panel and thermometer bulb supported to prevent kinks. Use minimum tubing length.

D. Thermometer Wells: Install in vertical position in piping tees where thermometers are indicated.

1. Install wells with stem extending minimum of two inches into fluid.
2. Fill wells with oil or graphite and secure caps.

3.4 PRESSURE GAUGE INSTALLATION

A. Install pressure gauges in piping tee with pressure gauge valve located on pipe at most readable position.

B. Install in the following locations and elsewhere as indicated:

1. At suction and discharge of each pump.
2. At discharge of each pressure-reducing valve.
3. At building water service entrance.

4. Pressure Gauge Needle Valves: Install in piping tee with snubber. Install syphon instead of snubber for steam pressure gauges.

3.5 CONNECTIONS

A. Piping installation requirements are specified in other Division 15 sections. The drawings indicate the general arrangement of piping, fittings and specialties.

B. Install meters and gauges adjacent to machines and equipment to allow servicing and maintenance.

3.6 ADJUSTING AND CLEANING

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

B. Adjusting: Adjust faces of meters and gauges to proper angle for best visibility.

C. Cleaning: Clean windows of meters and gauges and factory-finished surfaces. Replace cracked and broken windows and repair scratched and marred surfaces with manufacturer's touchup paint.

END OF SECTION

SECTION 15181 - HYDRONIC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes piping, special-duty valves, and hydronic specialties for hot-water heating, chilled-water cooling, and condenser water systems; makeup water for these systems; blowdown drain lines; and condensate drain piping.

1.2 SUBMITTALS

A. Product Data: For each type of special-duty valve indicated. Include flow and pressure drop curves based on manufacturer's testing for diverting fittings, calibrated balancing valves, and automatic flow-control valves.

B. Maintenance Data: For hydronic specialties and special-duty valves to include in maintenance manuals specified in Division 1.

C. Water Analysis: Submit a copy of the water analysis to illustrate water quality available at Project site.

1.3 QUALITY ASSURANCE

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

B. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.

C. International Mechanical Code: Comply with applicable sections.

1.4 COORDINATION

A. Coordinate layout and installation of hydronic piping and suspension system components with other construction, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.

B. Coordinate pipe sleeve installations for foundation wall penetrations.

C. Coordinate piping installation with roof curbs, equipment supports, and roof penetrations. Roof specialties are specified in Division 7 Sections.

D. Coordinate pipe fitting pressure classes with products specified in related Sections.

E. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into base. Concrete, reinforcement, and formwork requirements are specified in Division 3 Sections.

F. Coordinate installation of pipe sleeves for penetrations through exterior walls and floor assemblies. Coordinate with requirements for firestopping specified in Division 15 Section "Basic Mechanical Materials and Methods" for fire and smoke wall and floor assemblies.

1.5 EXTRA MATERIALS

A. Water Treatment Chemicals: Furnish sufficient chemicals for initial system startup and for preventive maintenance for one year from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Calibrated Balancing Valves:

a. Armstrong Pumps, Inc.
b. Flow Design, Inc.
c. Griswold Controls.
d. ITT Bell & Gossett; ITT Fluid Technology Corp.
e. Taco, Inc.

2. Pressure-Reducing Valves:

a. Amtrol, Inc.
b. Armstrong Pumps, Inc.
c. Conbraco Industries, Inc.
d. ITT Bell & Gossett; ITT Fluid Technology Corp.
e. Spence Engineering Company, Inc.
f. Watts Industries, Inc.; Watts Regulators.

3. Safety Valves:

a. Amtrol, Inc.
b. Armstrong Pumps, Inc.
c. Conbraco Industries, Inc.
d. ITT McDonnell & Miller Div.; ITT Fluid Technology Corp.
e. Kunkle Valve Division.
f. Spence Engineering Company, Inc.

4. Automatic Flow-Control Valves:

a. Flow Design, Inc.
b. Griswold Controls.

5. Expansion Tanks:

a. Amtrol, Inc.
b. Armstrong Pumps, Inc.

c. ITT Bell & Gossett; ITT Fluid Technology Corp.
d. Taco, Inc.

6. Air Separators and Air Purgers:

a. Amtrol, Inc.
b. Armstrong Pumps, Inc.
c. ITT Bell & Gossett; ITT Fluid Technology Corp.

2.2 PIPING MATERIALS

A. General: Refer to Part 3 "Piping Applications" Article for applications of pipe and fitting materials.

2.3 COPPER TUBE AND FITTINGS

A. Drawn-Temper Copper Tubing: ASTM B 88, Type L.

B. Annealed-Temper Copper Tubing: ASTM B 88, Type K.

C. Wrought-Copper Fittings: ASME B16.22.

D. Wrought-Copper Unions: ASME B16.22.

E. Solder Filler Metals: ASTM B 32, 95-5 tin antimony.

F. Brazing Filler Metals: AWS A5.8, Classification BAg-1 (silver).

2.4 STEEL PIPE AND FITTINGS

A. Steel Pipe, NPS 2 and Smaller: ASTM A 53, Type S (seamless) or Type F (furnace-butt welded), Grade A, Schedule 40, black steel, plain ends.

B. Steel Pipe, NPS 2-1/2 through NPS 12: ASTM A 53, Type E (electric-resistance welded), Grade A, Schedule 40, black steel, plain ends.

C. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125 and 250.

D. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300.

E. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300.

F. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 25, 125, and 250; raised ground face, and bolt holes spot faced.

G. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.

H. 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:

1. Material Group: 1.1.

2. End Connections: Butt welding.
3. Facings: Raised face.

I. Flexible Connectors: Stainless steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket; 150-psig minimum working pressure and 250 deg F maximum operating temperature. Connectors shall have flanged or threaded-end connections to match equipment connected and shall be capable of 3/4-inch misalignment. (2) grooved mechanical joint fittings my be used in lieu of flexible connector. Install per manufacturer's recommendations for flexible connectors.

J. Welding Materials: Comply with Section II, Part C, of the ASME Boiler and Pressure Vessel Code for welding materials appropriate for wall thickness and for chemical analysis of pipe being welded.

K. Gasket Material: Thickness, material, and type suitable for fluid to be handled; and design temperatures and pressures.

2.5 VALVES

A. Gate, globe, check, ball, and butterfly valves are specified in Division 15 Section "Valves."

B. Refer to Part 3 "Valve Applications" Article for applications of each valve.

C. Calibrated Balancing Valves, NPS 2 and Smaller: Bronze body, ball or plug type, 125-psig working pressure, 250 deg F maximum operating temperature, and having threaded ends. Valves shall have calibrated orifice or venturi, connections for portable differential pressure meter with integral seals, and be equipped with a memory stop to retain set position.

D. Calibrated Balancing Valves, NPS 2-1/2 and Larger: Cast-iron or steel body, ball or plug type, 125-psig working pressure, 250 deg F maximum operating temperature, and having flanged or grooved connections. Valves shall have calibrated orifice or venturi, connections for portable differential pressure meter with integral seals, and be equipped with a memory stop to retain set position.

E. Pressure-Reducing Valves: Diaphragm-operated, bronze or brass body with low inlet pressure check valve, inlet strainer removable without system shutdown, and non-corrosive valve seat and stem. Select valve size, capacity, and operating pressure to suit system. Valve shall be factory set at operating pressure and have capability for field adjustment.

F. Safety Valves: Diaphragm-operated, bronze or brass body with brass and rubber, wetted, internal working parts; shall suit system pressure and heat capacity and shall comply with the ASME Boiler and Pressure Vessel Code, Section IV.

G. Automatic Flow-Control Valves: Gray-iron body, factory set to maintain constant flow with plus or minus 5 percent over system pressure fluctuations, and equipped with a readout kit including flow meter, probes, hoses, flow charts, and carrying case. Each valve shall have an identification tag attached by chain, and be factory marked with the zone identification, valve number, and flow rate. Valve shall be line size and one of the following designs:

1. Gray-iron or brass body, designed for 175 psig at 200 deg F with stainless-steel piston and spring.

2. Brass or ferrous-metal body, designed for 300 psig at 250 deg F with corrosion-resistant, tamperproof, self-cleaning, piston-spring assembly easily removable for inspection or replacement.
3. Combination assemblies, including bronze ball valve and brass alloy control valve, with stainless-steel piston and spring, fitted with pressure and temperature test valves, and designed for 300 psig at 250 deg F.

H. Pump Discharge Valves; 175 psig working pressure, 300 F maximum operating temperature, cast-iron body, bronze disc and seat, stainless steel stem and spring and Teflon packing. Valves shall have flanged connections and straight or angle pattern as indicated. Features shall include non-slam check valve with spring loaded weighted disc and calibrated adjustment feature to permit regulation of pump discharge flow and shutoff.

2.6 HYDRONIC SPECIALTIES

A. Manual Air Vent: Bronze body and nonferrous internal parts; 150-psig working pressure; 225 deg F operating temperature; manually operated with screwdriver or thumbscrew; with NPS 1/8 discharge connection and NPS 1/2 inlet connection. Drain may also be used, see Section 3.3.

B. Automatic Air Vent: Designed to vent automatically with float principle; bronze body and nonferrous internal parts; 150-psig working pressure; 240 deg F operating temperature; with NPS 1/4 discharge connection and NPS 1/2 inlet connection.

C. Expansion Tanks: Welded carbon steel, rated for 125-psig working pressure and 375 deg F maximum operating temperature. Separate air charge from system water to maintain design expansion capacity by a flexible bladder securely sealed into tank. Include drain fitting and taps for pressure gage and air-charging fitting. Support vertical tanks with steel legs or base; support horizontal tanks with steel saddles. Factory fabricate and test tank with taps and supports installed and labeled according to the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.

D. Tangential-Type Air Separators: Welded black steel; ASME constructed and labeled for 125-psig minimum working pressure and 375 deg F maximum operating temperature; perforated stainless-steel air collector tube designed to direct released air into expansion tank; tangential inlet and outlet connections; threaded connections for NPS 2 and smaller; flanged connections for NPS 2-1/2 and larger; threaded blowdown connection. Provide units in sizes for full-system flow capacity.

E. Y-Pattern Strainers: 125-psig working pressure; cast-iron body (ASTM A 126, Class B), flanged ends for NPS 2-1/2 and larger, threaded connections for NPS 2 and smaller, bolted cover, perforated stainless-steel basket, and bottom drain connection.

F. Flexible Connectors: Stainless steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket; 150-psig minimum working pressure and 250 deg F maximum operating temperature. Connectors shall have flanged- or threaded-end connections to match equipment connected and shall be capable of 3/4-inch misalignment.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. Hot, Chilled Water, and Boiler Drain Piping, NPS 2 and Smaller: Aboveground, use Type L drawn-temper copper tubing with soldered joints, use Schedule 40 steel pipe with threaded joints. Below ground or within slabs, use Type K annealed-temper copper tubing with soldered joints. Use the fewest possible joints belowground and within floor slabs.

B. Hot and Chilled Water, NPS 2-1/2 and Larger: Schedule 40 steel pipe with welded and flanged joints.

C. Cooling Coil Condensate Drain Lines: Type L drawn-temper copper tubing with soldered joints.

3.2 VALVE APPLICATIONS

A. General-Duty Valve Applications: Unless otherwise indicated, use the following valve types:

1. Shutoff Duty: Ball and butterfly valves.
2. Throttling Duty: Globe, ball, and butterfly valves.

B. Install shutoff duty valves at each branch connection to supply mains, at supply connection to each piece of equipment, unless only one piece of equipment is connected in the branch line. Install throttling duty valves at each branch connection to return mains, at return connections to each piece of equipment, and elsewhere as indicated.

C. Install calibrated balancing valves in the return water line of each heating or cooling element and elsewhere as required to facilitate system balancing.

D. Install check valves at each pump discharge and elsewhere as required to control flow direction.

E. Install safety valves on hot-water generators and elsewhere as required by the ASME Boiler and Pressure Vessel Code. Install safety-valve discharge piping, without valves, to floor. Comply with the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, for installation requirements.

F. Install pressure-reducing valves on hot-water generators and elsewhere as required to regulate system pressure.

G. Install pump discharge valves where indicated on drawings. Check valve not required where pump discharge valve is used.

3.3 PIPING INSTALLATIONS

A. Refer to Division 15 Section "Basic Mechanical Materials and Methods" for basic piping installation requirements.

B. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

C. Install drains, consisting of a tee fitting, NPS 3/4 ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

D. Install piping at a uniform grade of 0.2 percent upward in direction of flow.

E. Reduce pipe sizes using eccentric reducer fitting installed with level side up.

F. Unless otherwise indicated, install branch connections to mains using tee fittings in main pipe, with the takeoff coming out the bottom of the main pipe. For up-feed risers, install the takeoff coming out the top of the main pipe.

G. Install strainers on supply side of each control valve, pressure-reducing valve, solenoid valve, in-line pump, and elsewhere as indicated. Install minimum NPS 3/4 nipple and ball valve in blowdown connection of strainers.

H. Anchor piping for proper direction of expansion and contraction.

I. Install other hydronic specialties of types and in locations indicated on drawings.

J. Install condensate drain lines for all cooling coil drain pans and condensing gas-fired heating equipment. Provide drain traps designed per manufacturers' instructions and to allow proper drainage. Extend piping the same size as the equipment connection to nearest floor drain, mop sink, or safe-waste.

3.4 HANGERS AND SUPPORTS

A. Hanger, support, and anchor devices are specified in Division 15 Section "Hangers and Supports." Comply with requirements below for maximum spacing of supports.

B. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal piping less than NPS 6.
2. Adjustable roller hangers and spring hangers for individual horizontal piping NPS or larger.
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 and horizontal piping first (3) hangers adjacent to vibrating equipment.

C. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:

1. NPS 3/4: Maximum span, 7 feet; minimum rod size, 1/4 inch.
2. NPS 1: Maximum span, 7 feet; minimum rod size, 1/4 inch.
3. NPS 1-1/2: Maximum span, 9 feet; minimum rod size, 3/8 inch.
4. NPS 2: Maximum span, 10 feet; minimum rod size, 3/8 inch.
5. NPS 2-1/2: Maximum span, 11 feet; minimum rod size, 3/8 inch.
6. NPS 3: Maximum span, 12 feet; minimum rod size, 3/8 inch.
7. NPS 4: Maximum span, 14 feet; minimum rod size, 1/2 inch.
8. NPS 6: Maximum span, 17 feet; minimum rod size, 1/2 inch.
9. NPS 8: Maximum span, 19 feet; minimum rod size, 5/8 inch.

D. Install hangers for drawn-temper copper piping with the following maximum spacing and minimum rod sizes:

1. NPS 3/4: Maximum span, 5 feet; minimum rod size, 1/4 inch.
2. NPS 1: Maximum span, 6 feet; minimum rod size, 1/4 inch.
3. NPS 1-1/2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
4. NPS 2: Maximum span, 8 feet; minimum rod size, 3/8 inch.

E. Support vertical runs at roof, at each floor, and at 10-foot intervals between floors.

3.5 PIPE JOINT CONSTRUCTION

A. Refer to Division 15 Section "Basic Mechanical Materials and Methods" for joint construction requirements for soldered and brazed joints in copper tubing; threaded, welded, and flanged joints in steel piping.

3.6 HYDRONIC SPECIALTIES INSTALLATION

A. Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.

B. Install bypass chemical feeders in each hydronic system where indicated, in upright position with top of funnel not more than 48 inches above floor. Install feeder in bypass line, off main, using ball or butterfly valves on each side within 12 inches of feeder and in the main between bypass connections. Pipe drain, with ball valve, to nearest equipment drain.

3.7 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 system with clean water. Clean strainers.
4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
5. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.

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 trapped air. Use drains installed at low points for complete draining of liquid.
3. Check expansion tanks to determine that they are not air bound and that system is full of water.
4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the design pressure.

Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed either 90 percent of specified minimum yield strength or 1.7 times "SE" value in Appendix A of ASME B31.9, "Building Services Piping."

5. After hydrostatic test pressure has been applied for at least 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.

3.8 PRE - CLEANING

A. Flush hydronic piping systems with clean water. Remove and clean or replace strainer screens. After cleaning and flushing hydronic piping systems, but before balancing, remove disposable fine-mesh strainers in pump suction diffusers.

3.9 ADJUSTING

A. Mark calibrated nameplates of pump discharge valves after hydronic system balancing has been completed, to permanently indicate final balanced position.

B. Perform these adjustments before operating the system:

1. Open valves to fully open position. Close coil bypass valves.
2. Check pump for proper direction of rotation.
3. Set automatic fill valves for required system pressure.
4. Check air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
5. Set temperature controls so all coils are calling for full flow.
6. Check operation of automatic bypass valves.
7. Check and set operating temperatures of boilers, chillers, and cooling towers to design requirements.
8. Lubricate motors and bearings.

END OF SECTION

SECTION 15185 – HYDRONIC PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following types of HVAC pumps for hydronic systems:

1. Inline circulators.
2. Flexible-Coupled, end-suction pumps

1.2 PERFORMANCE REQUIREMENTS

A. Pump Pressure Ratings: At least equal to system's maximum operating pressure at point where installed, but not less than specified.

1.3 SUBMITTALS

A. General: Submit each item in this Article according to the Conditions of the Contract and Division 1 Specification Sections.

B. Product data including certified performance curves and rated capacities of selected models, weights (shipping, installed and operating), furnished specialties, and accessories. Indicate pump's operating point on curves.

C. Wiring diagrams detailing wiring for power, signal and control systems, and differentiating between manufacturer-installed wiring and field-installed wiring.

D. Maintenance data for pumps to be included in the operation and maintenance manual specified in Division 1. Include startup instructions.

1.4 QUALITY ASSURANCE

A. Regulatory Requirements: Comply with provisions of the following:

1. ASME B31.9, Building Services Piping, for piping materials and installation.
2. Hydraulic Institute's Standards for Centrifugal, Rotary and Reciprocating Pumps, for pump design, manufacture, testing and installation.
3. UL 778, Standard for Motor Operated Water Pumps, for construction requirements. Include UL listing and labeling.
4. NEMA MG 1, Standard for Motors and Generators, for electric motors. Include NEMA listing and labeling.
5. NFPA 70, National Electrical Code, for electrical components and installation.

B. Single-Source Responsibility: Obtain each category of pumps from one source and by a single manufacturer.

C. Product Options: Drawings indicate sizes, profiles, connections and dimensional requirements of pumps and are based on the specific types and models indicated. Other manufacturers' pumps with equal performance characteristics may be considered.

1.5 DELIVERY, STORAGE AND HANDLING

A. Store pumps in dry location.

B. Retain shipping flange protective covers and protective coatings during storage.

C. Protect bearings and couplings against damage from sand, grit and other foreign matter.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated in the work are limited to the following to match existing at the facility:

1. Inline Circulators and flexible-coupled, end-suction pumps:

a. ITT Fluid Technology Corporation – Bell & Gossett
b. Taco, Inc.

2.2 PUMPS, GENERAL

A. General: Factory-assembled and tested.

B. Include pump casings that allow removal and replacement of impellers without disconnecting piping.

C. Types, Sizes, Capacities and Characteristics: As indicated.

D. Motors: NEMA MG-1, general purpose, continuous duty, Design B, except Design C where required for high starting torque. Furnish single-, multiple- or variable-speed motors with type of enclosures and electrical characteristics as indicated. Include built-in thermal-overload protection and grease-lubricated ball bearings. Select each motor to be nonover-loading over full range of the pump performance curve.

E. Factory Finish: Manufacturer's standard paint applied to factory-assembled and tested units before shipping.

2.3 INLINE CIRCULATORS

A. Description: Horizontal in-line, centrifugal, single-stage, bronze fitted, radially split case design, rated for 125 psig minimum working pressure and a continuous water temperature of 225F. Include the following:

1. Casing: Cast iron, with threaded companion flanges for piping connections smaller than 2-1/2" and threaded gage tappings at inlet and outlet connections.
2. Impeller: ASTM B 584, cast bronze, statically and dynamically balanced, closed, overhung, single-suction and keyed to shaft.
3. Shaft and Sleeve: Steel shaft with oil-lubricated copper sleeve.

4. Seals: Mechanical type. Include carbon-steel rotating ring, stain-less steel spring, ceramic seat, and flexible bellows and gasket.
5. Pump Bearings: Oil-lubricated, bronze journal and thrust type.
6. Motor Bearings: Oil-lubricated, sleeve type.
7. Coupling: Flexible, capable of absorbing torsional vibration and shaft misalignment.
8. Motor: Resiliently mounted to pump casing.

2.4 FLEXIBLE-COUPLED, END-SUCTION PUMPS

A. Description: Base-mounted, centrifugal, flexible-coupled, end-suction, single-stage, bronze-fitted, back-pull-out, radially split case design; rated for 175-psig minimum working pressure and a continuous water temperature of 225 deg F.

1. Casing: Cast iron, with flanged piping connections, drain plug at low point of volute, threaded gage tappings at inlet and outlet connections, and integral feet or other means on volute to support weight of casing and attached piping. Casing shall allow removal and replacement of impeller without disconnecting piping.
2. Impeller: ASTM B 584, cast bronze, statically and dynamically balanced, closed, overhung, single suction, keyed to shaft, and secured by locking cap screw.
3. Wear Rings: Replaceable, bronze casing ring.
4. Shaft and Sleeve: Steel shaft with bronze sleeve.
5. Seals: Mechanical, with carbon-steel rotating ring, stainless-steel spring, ceramic seat, and flexible bellows and gasket.
6. Coupling: Flexible-spacer type, capable of absorbing torsional vibration and shaft misalignment; with flange and sleeve section that can be disassembled and removed without removing pump or motor.
7. Coupling Guard: Steel, removable, and attached to mounting frame.
8. Mounting Frame: Welded-steel frame and cross members, factory fabricated from ASTM A 36/A 36M channels and angles. Fabricate for mounting pump casing, coupling guard, and motor. Field-drill motor-mounting holes for field-installed motors.

    a. Option: Cast-iron frames are acceptable.

9. Motor: Secured to mounting frame, with adjustable alignment.

2.6 PUMP SPECIALTY FITTINGS

A. Include the following pump specialty fittings with end connections matching pump and piping, where indicated:

1. Suction Diffuser: Angle or straight pattern, 175 psig pressure rating, cast-iron body and end cap, pump-inlet fitting.

    Include bronze startup and bronze or stainless steel permanent strainers; bronze or stainless steel straightening vanes; drain plug; and factory- or field-fabricated support.

2. Triple-Duty Valve: Angle or straight pattern, 175 psig pressure rating, cast-iron body, pump discharge fitting. Include drain plug and bronze fitted shutoff, balancing, and check valve features.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, equipment foundations and conditions, with installer present, for compliance with requirements for installation and other conditions affecting performance of pumps.

B. Examine roughing-in for piping systems to verify actual locations of piping connections before pump installation.

C. Examine foundations and inertia bases for suitable conditions where pumps are to be installed.

D. Do not proceed until unsatisfactory conditions have been corrected.

3.2 CONCRETE

A. Install concrete bases of dimensions indicated for pumps. Refer to Division 3 Section, Cast-in-Place Concrete, and Division 15 Section, Basic Mechanical Materials and Methods.

3.3 INSTALLATION

A. Install pumps according to manufacturer's written installation and alignment instructions.

B. Install pumps in locations and arranged to provide access for periodic maintenance, including removal of motors, impellers, couplings and accessories.

C. Support pumps and piping separately so that piping is not supported by pumps.

D. Suspend inline pumps using continuous-thread hanger rod and vibration isolation hangers of sufficient size to support the weight of the pump independent of piping system.

3.4 ALIGNMENT

A. Align pump and motor shafts and piping connections after setting on foundations, after grout has been set and foundation bolts have been tightened, and after piping connections have been made.

B. Comply with pump & coupling manufacturer written instructions.

C. Adjust alignment of pump and motor shafts for angular and parallel alignment by one of two methods specified in the H.I.'s Standard for Centrifugal, Rotary and Reciprocating Pumps, Instructions for Installation, Operation and Maintenance.

D. After alignment is correct, tighten the foundation bolts evenly, but not too firmly. Fill the base plate completely with non-shrink, nonmetallic grout, with metal blocks and shims or wedges in place. After grout has cured, fully tighten foundation bolts.

E. Alignment Tolerances: To manufacturer recommendations.

3.5 CONNECTIONS

A. General: Install shutoff valve and strainer on pump suction and check valve and shutoff valve on pump discharge, except where other arrangement is indicated.

B. Connect piping to pumps as indicated. Install valves that are the same size as piping connecting to pumps.

C. Install suction and discharge pipe sizes equal to or greater than the diameter of the pump nozzles.

D. Install thermometers where indicated.

E. Install pressure gages on pump suction and discharge. Install at integral pressure gage tappings where provided.

3.6 FIELD QUALITY CONTROL

A. Check suction piping connections for tightness to avoid drawing air into pumps.

B. Clean strainers.

C. Set pump controls.

3.7 COMMISSIONING

A. Final Checks before Start-Up: Perform the following preventative maintenance operations and checks before start-up:

1. Lubricate bearings.
2. Remove grease-lubricated bearing covers, flush bearings with kerosene and clean thoroughly. Fill with new lubricant according to manufacturer's recommendations.
3. Disconnect coupling and check motor for proper rotation that matches direction marked on pump casing.
4. Check that pumps are free to rotate by hand. Pumps for handling hot liquids shall be free to rotate with pump hot and cold. Do not operate the pump if it is bound or even drags slighting until cause of trouble is determined and corrected.
5. Check that pump controls are correct for required application.

B. Starting procedure for pumps with shutoff power not exceeding the safe motor power.

1. Prime pumps, opening suction valve, closing drains and preparing pumps for operation.
2. Open cooling water supply valves in cooling water supply to bearings, where applicable.
3. Open the cooling water supply valves if stuffing boxes are water-cooled.
4. Open sealing liquid supply valves if pumps are so fitted.
5. Open warm-up valves of pumps handling hot liquids if pumps are not normally kept at operating temperature.
6. Open circulating line valves if pumps should not be operated against dead shutoff.
7. Start motors.
8. Open discharge valves slowly.
9. Observe leakage from stuffing boxes and adjust sealing liquid valve for proper flow to ensure lubrication of packing. Let the packing "run in" before reducing leakage through stuffing boxes; then tighten glands.
10. Check general mechanical operation of pumps and motors.
11. Close circulating line valves once there is sufficient flow through pumps to prevent overheating.

C. When pumps are to be started against closed check valves with discharge shutoff valves open, steps are the same, except that discharge valves are opened some time before motors are started.

D. Refer to Division 15 Section, Testing, Adjusting and Balancing, for detailed requirements for testing, adjusting and balancing hydronic systems.

END OF SECTION

SECTION 15194 - FUEL GAS PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes piping, specialties, and accessories for natural gas systems within building and to gas meters.

B. This Section includes piping, specialties, and accessories for natural gas systems within building and to point indicated.

1.3 DEFINITIONS

A. Low-Pressure Natural Gas Piping: Operating pressure of 0.5 psig or less.

B. Gas Service: Pipe from gas main or other source to gas point of delivery for building being served. Piping includes gas service piping, gas valve, service pressure regulator, meter bar or meter support, and gas meter.

1.4 SYSTEM PERFORMANCE REQUIREMENTS

A. Minimum Working-Pressure Ratings: Except where otherwise indicated, minimum pressure requirements are as follows:

1. Low-Pressure Natural Gas Piping: 0.25 psig.

B. Approximate values of natural gas supplied for these systems are as follows:

1. Heating Value: 1000 Btu/cu. ft.
2. Specific Gravity: 0.6.
3. Service Line Pressure: 15 to 20 psig.

1.5 SUBMITTALS

A. General: Submit each item in this Article according to the Conditions of the Contract and Division 1 Specification Sections.

B. Product Data for each type of natural gas specialty and special-duty valve. Include pressure rating, rated capacity, and settings of selected models.

C. Coordination Drawings for natural gas piping, including required clearances and relationship to other services for same work areas.

D. Test reports specified in "Field Quality Control" Article in Part 3.

E. Maintenance data for natural gas specialties and special-duty valves to include in the operation and maintenance manual specified in Division 1 Section "Contract Closeout."

1.6 QUALITY ASSURANCE

A. Comply with NFPA 54, "National Fuel Gas Code," for gas piping materials and components; installations; and inspecting, testing, and purging.

B. Comply with NFPA 70, "National Electrical Code," for electrical connections between wiring and electrically operated control devices.

C. Provide listing/approval stamp, label, or other marking on equipment made to specified standards.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Handling Flammable Liquids: Remove and legally dispose of liquids from drips in existing gas piping. Handle cautiously to avoid spillage and ignition. Notify gas supplier. Handle flammable liquids used by Installer with proper precautions and do not leave on premises from end of one day to beginning of next day.

1.8 SEQUENCING AND SCHEDULING

A. Notification of Interruption of Service: Notify each affected user when gas supply will be turned off.

B. Work Interruptions: Leave gas piping systems in safe condition when interruptions in work occur during repairs or alterations to existing gas piping systems.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

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

1. Gas Stops, 2-Inch NPS and Smaller:

    a. Hammond Valve Corp.
    b. Jomar International, Ltd.
    c. Maxitrol Co.
    d. McDonald: A.Y. McDonald Mfg. Co.
    e. Milwaukee Valve Co., Inc.
    f. Mueller Co.
    g. National Meter.

2. Gas Valves, 2-1/2-Inch NPS and Larger:

    a. Core Industries, Inc.; Mueller Steam Specialty Div.

b. Huber: J.M. Huber Corp.; Flow Control Div.
c. Milliken Valve Co., Inc.
d. Nordstrom Valves, Inc.
e. Olson Technologies, Inc.
f. Xomox Corp.

3. Gas Pressure Regulators:

a. American Meter Co.
b. Fisher Controls International, Inc.
c. Equimeter, Inc.
d. Maxitrol Co.
e. National Meter.
f. Richards Industries, Inc.; Jordan Valve Div.
g. Schlumberger Industries; Gas Div.

2.2 PIPES AND TUBES

A. Steel Pipe: ASTM A 53; Type E, electric-resistance welded or Type S, seamless; Grade B; Schedule 40; black.

2.3 PIPE AND TUBE FITTINGS

A. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern, with threaded ends conforming to ASME B1.20.1.

B. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends conforming to ASME B1.20.1.

C. Cast-Iron Flanges and Flanged Fittings: ASME B16.1, Classes 125 and 250.

2.4 JOINING MATERIALS

A. Common Joining Materials: Refer to Division 15 Section "Basic Mechanical Materials and Methods" for joining materials not included in this Section.

B. Joint Compound and Tape: Suitable for natural gas.

D. Gasket Material: Thickness, material, and type suitable for natural gas.

2.5 VALVES

A. Manual Valves: Conform to standards listed or, where appropriate, to ANSI Z21.15.

B. Gas Stops, 2-Inch NPS and Smaller: AGA-certified, bronze-body, plug type with bronze plug, ball type with chrome-plated brass ball, or butterfly valve with stainless-steel disc and fluorocarbon elastomer seal, for 2 psig or less natural gas. Include AGA stamp, flat or square head or lever handle, and threaded ends conforming to ASME B1.20.1.

1. Locking Device: Include locking (tamperproof) feature.

C. Gas Valves, 2-1/2-Inch NPS and Larger: MSS SP-78, Class 125 or Class 175 WOG, nonlubricated-plug type with polytetrafluoroethylene (PTFE) lining or sleeve, semisteel body, wrench operated, with flanged ends.

1. Locking Device: Include locking (tamperproof) feature.

2.6 PIPING SPECIALTIES

A. Gas Pressure Regulators: ANSI Z21.18, single-stage, steel-jacketed, corrosion-resistant pressure regulators. Include atmospheric vent, elevation compensator, with threaded ends conforming to ASME B1.20.1 for 2-inch NPS and smaller and flanged ends for 2-1/2-inch NPS and larger. Regulator pressure ratings, inlet and outlet pressures, and flow volume in cubic feet per hour of natural gas at specific gravity are as indicated.

1. Line Gas Pressure Regulators: Inlet pressure rating not less than system pressure.
2. Appliance Gas Pressure Regulators: Inlet pressure rating not less than system pressure, with capacity and pressure setting matching appliance.
3. Gas Pressure Regulator Vents: Factory- or field-installed corrosion-resistant screen in opening when not connected to vent piping.

B. Flexible Connectors: ANSI Z21.24, copper alloy.

C. Strainers: Y pattern, full size of connecting piping. Include stainless-steel screens with 3/64-inch perforations, except where other screens are indicated.

1. Pressure Rating: 125-psig minimum steam or 175-psig WOG working pressure, except where otherwise indicated.
2. 2-Inch NPS and Smaller: Bronze body, with threaded ends conforming to ASME B1.20.1.
3. 2-1/2-Inch NPS and Larger: Cast-iron body, with flanged ends.
4. Screwed screen retainer with centered blow-down and pipe plug.

2.7 PROTECTIVE COATING

A. Furnish pipe and fittings with factory-applied, corrosion-resistant polyethylene coating for use in corrosive atmosphere. Coating properties include the following:

1. Applied to pipe and fittings treated with compatible primer before applying tape.
2. Overall Thickness: 20 mils, synthetic adhesive.
3. Water-Vapor Transmission Rate: Maximum 0.10 gal./100 sq. in.
4. Water Absorption: 0.02 percent maximum.

PART 3 - EXECUTION

3.1 PREPARATION

A. Close equipment shutoff valves before turning off gas to premises or section of piping. Perform leakage test as specified in "Field Quality Control" Article to determine that all equipment is turned off in affected piping section.

B. Comply with NFPA 54 Paragraph "Prevention of Accidental Ignition."

3.2 SERVICE ENTRANCE PIPING

A. Extend natural gas piping and connect to gas distribution system (gas service) piping in location and size indicated for gas service entrance to building.

1. Gas distribution system piping, service pressure regulator, and gas meter will be provided by gas utility.

B. Install shutoff valve, downstream from gas meter, outside building at gas service entrance.

3.3 PIPING APPLICATIONS

A. General: Flanges, unions, transition and special fittings, and valves with pressure ratings same as or higher than system pressure rating may be used in applications below, except where otherwise indicated.

B. Low-Pressure, 0.5 psig or Less, Natural Gas Systems: Use the following:

1. 2-Inch NPS and Smaller: Steel pipe, malleable-iron threaded fittings, and threaded joints.
2. 2-Inch NPS and Larger: Steel pipe, butt-welding fittings, and welded joints.

C. Underground Natural Gas Systems, All Pressures: Steel pipe, butt-welding fittings, and welded joints. Encase gas carrier piping in containment conduits.

D. Underground Containment Conduits: Steel pipe, butt-welding fittings, and welded joints.

3.4 VALVE APPLICATIONS

A. Use gas stops for shutoff to appliances with 2-inch NPS or smaller low-pressure gas supply.

B. Use gas valves for shutoff to appliances with 2-1/2-inch NPS or larger low-pressure gas supply and all sizes for medium-pressure gas supply.

C. Use gas valves of sizes indicated for gas service piping, meters, mains, and where indicated.

3.5 PIPING INSTALLATIONS

A. Refer to Division 15 Section "Basic Mechanical Materials and Methods" for basic piping installation requirements.

B. Concealed Locations: Except as specified below, install concealed gas piping in airtight conduit constructed of Schedule 40, seamless, black steel pipe with welded joints. Vent conduit to outside and terminate with screened vent cap.

1. Above-Ceiling Locations: Gas piping may be installed in accessible spaces, subject to approval of authorities having jurisdiction, whether or not such spaces are used as plenums. Do not locate valves in such spaces.

2. In Floors: Gas piping with welded joints and protective wrapping specified in "Protective Coating" Article in Part 2 may be installed in floors, subject to approval of authorities having jurisdiction. Surround piping cast in concrete slabs with minimum of 1-1/2 inches of concrete.

Piping may not be in physical contact with other metallic structures such as reinforcing rods or electrically neutral conductors. Do not embed piping in concrete slabs containing quick-set additives or cinder aggregate.

3. In Floor Channels: Gas piping may be installed in floor channels, subject to approval of authorities having jurisdiction. Channels must have cover and be open to space above cover for ventilation.
4. In Partitions: Do not install concealed piping in solid partitions. Protect tubing from physical damage when installed inside partitions or hollow walls.

    a. Exception: Tubing passing through partitions or walls.

5. In Walls: Gas piping with welded joints and protective wrapping specified in "Protective Coating" Article in Part 2 may be installed in masonry walls, subject to approval of authorities having jurisdiction.
6. Prohibited Locations: Do not install gas piping in or through circulating air ducts, clothes or trash chutes, chimneys or gas vents (flues), ventilating ducts, or dumbwaiter or elevator shafts.

    a. Exception: Accessible above-ceiling space specified above.

C. Drips and Sediment Traps: Install drips at points where condensate may collect. Include outlets of gas meters. Locate where readily accessible to permit cleaning and emptying. Do not install where condensate would be subject to freezing.

1. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use minimum-length nipple of 3 pipe diameters, but not less than 3 inches long, and same size as connected pipe. Install with space between bottom of drip and floor for removal of plug or cap.

D. Conceal pipe installations in walls, pipe spaces, utility spaces, above ceilings, below grade or floors, and in floor channels, except where indicated to be exposed to view.

E. Install gas piping at uniform grade of 0.1 percent slope upward toward risers.

F. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.

G. Connect branch piping from top or side of horizontal piping.

H. Install unions in pipes 2-inch NPS and smaller, adjacent to each valve, at final connection to each piece of equipment, and elsewhere as indicated. Unions are not required on flanged devices.

I. Install strainers on supply side of each control valve, gas pressure regulator, solenoid valve, and elsewhere as indicated.

J. Install dielectric fittings (unions and flanges) with ferrous and brass or bronze end connections, separated by insulating material, where piping of dissimilar metals is joined.

K. Install dielectric fittings (unions and flanges) with 2 ferrous end connections, separated by insulating material, at outlet from gas meter and, where indicated, for ferrous piping.

L. Install flanges on valves, specialties, and equipment having 2-1/2-inch NPS and larger connections.

M. Anchor piping to ensure proper direction of piping expansion and contraction. Install expansion joints, expansion loops, and pipe guides as indicated.

N. Install vent piping for gas pressure regulators and gas trains, extend outside building, and vent to atmosphere. Terminate vents with turned-down, reducing-elbow fittings with corrosion-resistant insect screens in large end.

O. Install containment conduits for gas piping below slabs, within building, in gastight conduits extending minimum of 4 inches outside building, and vented to atmosphere. Terminate vents with turned-down, reducing-elbow fittings with corrosion-resistant insect screens in large end. Prepare and paint outside of conduits with coal-tar epoxy-polyamide paint according to SSPC-Paint 16.

3.6 JOINT CONSTRUCTION

A. Refer to Division 15 Section "Basic Mechanical Materials and Methods" for basic piping joint construction.

3.7 VALVE INSTALLATION

A. Install valves in accessible locations, protected from damage. Tag valves with metal tag indicating piping supplied. Attach tag to valve with metal chain.

1. Refer to Division 15 Section "Basic Mechanical Materials and Methods" for valve tags.
2. Refer to Division 15 Section "Mechanical Identification" for valve tags.

B. Install gas valve upstream from each gas pressure regulator. Where 2 gas pressure regulators are installed in series, valve is not required at second regulator.

C. Install pressure relief or pressure-limiting devices so they can be readily operated to determine if valve is free; test to determine pressure at which they will operate; and examine for leakage when in closed position.

3.8 HANGER AND SUPPORT INSTALLATION

A. Refer to Division 15 Section "Hangers and Supports" for pipe hanger and support devices.

B. Install hangers for horizontal steel piping with the following maximum spacing and minimum rod sizes:

1. 1/2-Inch NPS: Maximum span, 72 inches; minimum rod size, 3/8 inch.
2. 3/4- and 1-Inch NPS: Maximum span, 96 inches; minimum rod size, 3/8 inch.
3. 1-1/4-Inch NPS: Maximum span, 108 inches; minimum rod size, 3/8 inch.
4. 1-1/2- and 2-Inch NPS: Maximum span, 108 inches; minimum rod size, 3/8 inch.
5. 2-1/2- to 3-1/2-Inch NPS: Maximum span, 10 feet; minimum rod size, 1/2 inch.
6. 4-Inch NPS and Larger: Maximum span, 10 feet; minimum rod size, 5/8 inch.

C. Install hangers for horizontal drawn-temper copper tubing with the following maximum spacing and minimum rod sizes:

1. 3/8-Inch NPS: Maximum span, 48 inches; minimum rod size, 3/8 inch.
2. 1/2- and 5/8-Inch NPS: Maximum span, 72 inches; minimum rod size, 3/8 inch.
3. 3/4- and 7/8-Inch NPS: Maximum span, 84 inches; minimum rod size, 3/8 inch.
4. 1-Inch NPS: Maximum span, 96 inches; minimum rod size, 3/8 inch.

D. Support vertical pipe and tube at each floor.

3.9 CONNECTIONS

A. Install gas piping next to equipment and appliances using gas to allow service and maintenance.

B. Connect gas piping to equipment and appliances using gas with shutoff valves and unions. Install gas valve upstream from and within 72 inches of each appliance using gas. Install union or flanged connection downstream from valve. Include flexible connectors when indicated.

C. Sediment Traps: Install tee fitting with capped nipple in bottom forming drip, as close as practical to inlet for appliance using gas.

D. Electrical Connections: Wiring is specified in Division 16 Sections.

3.10 ELECTRICAL BONDING AND GROUNDING

A. Install aboveground portions of natural gas piping systems that are upstream from equipment shutoff valves, electrically continuous, and bonded to grounding electrode according to NFPA 70.

B. Do not use gas piping as grounding electrode.

3.11 FIELD QUALITY CONTROL

A. Inspect, test, and purge piping according to NFPA 54, Part "Gas Piping Inspection, Testing, and Purging" and requirements of authorities having jurisdiction.

B. Repair leaks and defects with new materials and retest system until satisfactory results are obtained.

C. Report test results promptly and in writing to Architect and authorities having jurisdiction.

D. Verify capacities and pressure ratings of regulators, valves, and specialties.

E. Verify correct pressure settings for pressure regulators.

F. Verify that specified piping tests are complete.

3.12 ADJUSTING

A. Adjust controls and safety devices. Replace damaged and malfunctioning controls and safety devices.

END OF SECTION

SECTION 15512 - CONDENSING BOILERS

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 gas-fired, water-tube, floor-mounted condensing boilers, trim, and accessories for generating hot water.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for boilers.
2. Include rated capacities, operating characteristics, and furnished specialties and accessories.

B. Shop Drawings: For boilers, boiler trim, and accessories.

1. Include plans, elevations, sections, and mounting details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans and sections, drawn to scale and coordinated with each other, using input from installers of the items involved.

B. Source quality-control reports.

C. Field quality-control reports.

D. Sample Warranty: For special warranty.

E. Product Certificates:

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For boilers to include in emergency, operation, and maintenance manuals.

1.6 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of boilers that fail in materials or workmanship within specified warranty period. Where "prorated" is indicated, the boiler manufacturer will cover the indicated percentage of cost of replacement parts. With "prorated" type, covered cost decreases as age of equipment increases.

1. Warranty Period for Floor-Mounted Water-Tube Condensing Boilers:

a. Heat Exchanger and Tank: Free from defects in material and workmanship.
b. Warranty Coverage: 5 years from date of Substantial Completion.

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 boilers to comply with ASME Boiler and Pressure Vessel Code.

C. ASHRAE/IES 90.1 Compliance: Boilers shall have minimum efficiency in accordance with Table 6.8.1-6 and other requirements in Ch. 6 of ASHRAE/IES 90.1.

D. Mounting Base: For securing boiler to concrete base.

2.2 FLOOR-MOUNTED, WATER-TUBE CONDENSING BOILERS

A. MANUFACTURERS

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products which may be incorporated in the work include, but are not limited to, the following:

a. AERCO
b. LOCHINVAR
c. FULTON
d. WEIL-MCLAIN

B. Description: Factory-fabricated, -assembled, and -tested, water-tube, forced-draft, condensing boiler with heat exchanger sealed pressure tight, built on a steel base, including insulated jacket; flue-gas vent; combustion-air intake connections; water supply, return, and condensate drain connections; and controls. Units are to be for water-heating service only.

C. Heat Exchanger: Stainless steel primary and secondary heat exchangers.

D. Combustion Chamber: Stainless steel, sealed.

E. Burner: Natural gas, forced draft drawing from gas-premixing valve.

F. Blower: Centrifugal fan to operate during each burner-firing sequence and to prepurge and postpurge the combustion chamber.

1. Motors: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 15055 "Motors"

a. Motor Sizes: Large enough so driven load will not require motor to operate in service factor range above 1.0.

G. Gas Train: Combination gas valve with manual shutoff and pressure regulator.

H. Ignition: Direct-spark ignition or silicone carbide hot-surface ignition with 100 percent main-valve shutoff and electronic flame supervision.

I. Integral Circulator: Cast-iron body and stainless steel impeller sized for minimum flow required in heat exchanger.

J. Casing:

1. Jacket: Sheet metal, with snap-in or interlocking closures.
2. Control Compartment Enclosures: NEMA 250, Type 1A.
3. Finish: Powder-coated protective finish.
4. Insulation: Minimum 1-inch-thick, mineral-fiber insulation surrounding the heat exchanger.
5. Combustion-Air Connections: Inlet and vent duct collars.

K. Capacities and Characteristics:

1. Heating Medium: Refer to schedules on plans
2. Minimum Efficiency AFUE: 95 percent.
3. Minimum Thermal Efficiency: 97 percent.
4. Minimum Combustion Efficiency: 95 percent.

2.3 TRIM - FOR HOT-WATER BOILERS

A. Aquastat Controllers: Operating, firing rate, and high limit with automatic reset.

B. Safety Relief Valve: ASME rated.

C. Pressure and Temperature Gauge: Minimum 3-1/2-inch-diameter, combination water-pressure and -temperature gauge. Gauges shall have operating-pressure and -temperature ranges, so normal operating range is about 50 percent of full range.

D. High and low gas-pressure switches.

E. Alarm bell with silence switch.

F. Boiler Air Vent: Automatic

G. Drain Valve: Minimum NPS 3/4 hose-end gate valve.

H. Circulation Pump: Nonoverloading, in-line pump with split-capacitor motor having thermal-overload protection and lubricated bearings; designed to operate at specified boiler pressures and temperatures. P-5 and P-6 on plans.

2.4 CONTROLS

A. Refer to Section 15900 HVAC INSTRUMENTATION AND CONTROLS and Section 15985 SEQUENCE OF OPERATION.

B. Burner Operating Controls: To maintain safe operating conditions, burner safety controls limit burner operation.

1. High Cutoff: Manual reset stops burner if operating conditions rise above maximum boiler design temperature.
2. Low-Water Cutoff Switch: Electronic probe shall prevent burner operation on low water. Cutoff switch shall be manual-reset type.
3. Blocked Inlet Safety Switch: Manual-reset pressure switch factory mounted on boiler combustion-air inlet.
4. Audible Alarm: Factory mounted on control panel with silence switch; shall sound alarm for above conditions.

C. Building Automation System Interface: Factory install hardware and software to enable building automation system to monitor, control, and display boiler status and alarms.

1. Hardwired Points:

a. Monitoring: On/off status, low-water-level alarm
b. Control: On/off operation, hot-water-supply temperature set-point adjustment

2. A BACnet communication interface with building automation system shall enable building automation system operator to remotely control and monitor the boiler from an operator workstation. All monitoring and control features, which are available at the local boiler control panel, shall also be available at the remote operator workstation through the building automation system.

2.5 ELECTRICAL POWER

A. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are shown on Drawings and specified in electrical Sections.

B. Single-Point Field Power Connection: Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to boiler.

1. House in NEMA 250, Type 1 enclosure.
2. Wiring shall be numbered and color coded to match wiring diagram.
3. Install factory wiring outside of an enclosure in a metal raceway.
4. Field power interface shall be to nonfused disconnect switch
5. Provide branch power circuit to each motor and to controls with a disconnect switch
6. Provide each motor with overcurrent protection.

2.6 VENTING KITS

A. Kit: Complete system, ASTM A959, Type 29-4C stainless steel pipe, vent terminal, thimble, indoor plate, vent adapter, condensate trap and dilution tank, and sealant.

B. Combustion-Air Intake: Complete system, stainless steel pipe, vent terminal with screen, inlet air coupling, and sealant.

2.7 CONDENSATE-NEUTRALIZATION UNITS

A. Description: Factory-fabricated and -assembled condensate-neutralizing capsule assembly of corrosion-resistant plastic material with threaded or flanged inlet and outlet pipe connections. Device functions to prevent acidic condensate from damaging grain system. It is to be piped to receive acidic condensate discharged from condensing boiler and neutralize it by chemical reaction with replaceable neutralizing agent. Neutralized condensate is then piped to suitable drain.

B. Capsule features:

1. All corrosion-resistant material.
2. Suitable for use on all natural gas and propane boilers.
3. Includes initial charge of neutralizing agent.
4. Neutralizing agent to be easily replaceable when exhausted.
5. Inlet and outlet pipe connections.

C. Capsule Configuration:

1. Low-profile design for applications where boiler condensate drain is close to the floor.
2. Easily removed and opened for neutralizing agent replacement.
3. Multiple units may be used for larger capacity.

D. Tank Configuration:

1. Utilized where boiler is elevated or where tank is installed in a pit with tank top flush with floor.
2. Top easily removed for neutralizing agent replacement.
3. Internal baffles to channel flow for complete neutralization.
4. Integral bypass to prevent condensate backflow into appliance.
5. Multiple units may be used for larger capacity.

2.8 SOURCE QUALITY CONTROL

A. UL Compliance: Test gas-fired boilers having input of more than 400,000 Btu/h for compliance with UL 795. Boilers shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.

B. UL Compliance, Gas-Fired: Test gas-fired boilers for compliance with UL 2764. Boilers shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.

C. Performance Testing: Test and label boilers for efficiency to comply with AHRI 1500.

D. Burner and Hydrostatic Test: Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency; perform hydrostatic test.

E. Test and inspect factory-assembled boilers, before shipping, in accordance with 2017 ASME Boiler and Pressure Vessel Code. Factory test boilers for safety and functionality; fill boiler with water, and fire throughout firing range, to prove operation of all safety components.

F. Contact Architect 14 days in advance of testing.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, and piping and electrical connections to verify actual locations, sizes, and other conditions affecting performance of the Work.

1. Final boiler locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.

B. Examine mechanical spaces for suitable conditions where boilers will be installed.

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

3.2 BOILER INSTALLATION

A. Equipment Mounting:

1. Install floor-mounted boilers on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations.
2. Comply with requirements for vibration isolation devices.

B. Install gas-fired boilers according to NFPA 54.

C. Assemble and install boiler trim.

D. Install electrical devices furnished with boiler but not specified to be factory mounted.

E. Install control wiring to field-mounted electrical devices.

3.3 PIPING CONNECTIONS

A. Comply with requirements for hydronic piping specified in Section 15181 "Hydronic Piping."

B. Connect piping to boilers, except safety relief valve connections, with flexible connectors of materials suitable for service. Flexible connectors and their installation are specified in Section 15181.

C. Drawings indicate general arrangement of piping, fittings, and specialties.

D. When installing piping adjacent to boiler, allow space for service and maintenance of condensing boilers. Arrange piping for easy removal of condensing boilers.

E. Install condensate drain piping to condensate-neutralization unit and from neutralization unit to nearest floor drain. Piping shall be at least full size of connection. Install piping with a minimum of 2 percent downward slope in direction of flow.

F. Connect gas piping to boiler gas-train inlet with union. Piping shall be at least full size of gas-train connection. Provide a reducer if required.

G. Connect hot-water piping to supply- and return-boiler tappings with shutoff valve, and union or flange at each connection.

H. Install piping from safety relief valves to nearest floor drain.

3.4 DUCT CONNECTIONS

A. Boiler Venting:

1. Field fabricate and install boiler vent and combustion-air intake.
2. Utilize vent and intake duct material, size, and configuration as indicated in boiler manufacturer's instructions and to comply with UL 1738.
3. Comply with all boiler manufacturer's installation instructions.

3.5 ELECTRICAL CONNECTIONS

A. Connect wiring in accordance with Section "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.

D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in "Identification for Electrical Systems."
2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch high.

3.6 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring in accordance with "Control-Voltage Electrical Power Cables."

C. Install nameplate for each control connection, indicating field control panel designation and I/O control designation feeding connection.

1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in "Identification for Electrical Systems."
2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch high.

3.7 FIELD QUALITY CONTROL

A. Perform tests and inspections with the assistance of a factory-authorized service representative:

B. Tests and Inspections:

1. Perform installation and startup checks in accordance with manufacturer's written instructions.
2. Leak Test: Hydrostatic test. Repair leaks and retest until no leaks exist.
3. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

    a. Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level, and water temperature.
    b. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

C. Boiler will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

E. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain boilers. Refer to Section "Demonstration and Training."

1. Instructor shall be factory trained and certified.
2. Train personnel in operation and maintenance and to obtain maximum efficiency in plant operation.
3. Provide instructional videos showing general operation and maintenance that are coordinated with operation and maintenance manuals.
4. Obtain Owner sign-off that training is complete.
5. Owner training shall be held at Project site.

END OF SECTION

SECTION 15550 - BREECHINGS, CHIMNEYS AND STACKS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:

1. Type B gas vents.
2. Steel, positive-pressure, double-wall vents.
4. Fabricated metal breechings.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories.

B. Shop Drawings: Show fabrication and installation details for breechings, chimneys, and stacks. Include plans, elevations, sections, details, and attachments to other Work. Detail assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, hangers and location and size of each field connection.

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

D. Engineering Report: Certifying that stacks meet the design wind loads.

1.4 QUALITY ASSURANCE

A. Manufacturer Qualifications: A firm experienced in manufacturing refractory-lined stacks similar to those indicated for this Project and with a record of successful in-service performance.

B. Source Limitations: Obtain Type B vent system components through one source from a single manufacturer.

C. Welding Standards: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code--Steel," for hangers and supports, and AWS D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.

D. Comply with AWS D1.1 for welder qualifications, welding details, and workmanship standards.

E. Comply with SMACNA's "Guide for Steel Stack Design and Construction."

F. Comply with SMACNA's "HVAC Duct Construction Standards, Metal and Flexible" for fabricated breechings.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

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

1. Type B Gas Vents:

a. Hart & Cooley, Inc.
b. Selkirk Metalbestos.
c. United McGill Corp.; Airflow Group.
d. Van-Packer Co.

2. Steel, Positive-Pressure, Double-Wall Vents:

a. Hart & Cooley, Inc.
b. Selkirk Metalbestos.
c. Van-Packer Co.

2.2 TYPE B GAS VENTS

A. Description: Double-wall gas vents complying with NFPA 211, Type B. Inner pipe of sheet aluminum, outer pipe of galvanized-steel sheet, each with the following minimum thicknesses:

1. Round, 6-Inch and Smaller ID: 0.012-inch inner pipe, 0.0187-inch outer pipe.
2. Round, 7- to 18-Inch ID: 0.014-inch inner pipe, 0.0187-inch outer pipe.
3. Round, 20- to 24-Inch ID: 0.018-inch inner pipe, 0.0217-inch outer pipe.

B. Accessories: Tees, elbows, increasers, draft hood connectors, metal cap with bird barrier, adjustable roof flashing, storm collar, support assembly, thimbles, firestop spacers, and fasteners; fabricated of similar materials and designs as vent-pipe straight sections.

2.3 STEEL, POSITIVE-PRESSURE, DOUBLE-WALL VENTS

A. Description: Double-wall metal stacks complying with NFPA 211, suitable for use with building heating equipment burning gas, solid, or liquid fuels.

B. Construction: Inner and outer metal shells separated by at least 1/2-inch airspace, with positive sealing joints.

C. Construction: Inner and outer metal shells separated by at least 1-inch airspace, with positive sealing joints.

D. Inner Shell: ASTM A 666, Type 304 stainless steel of the following thicknesses:

1. 6- to 36-Inch Size: 0.035 inch thick.
2. 42- to 48-Inch Size: 0.048 inch thick.

E. Outer Jacket: Aluminum-coated steel of the following thicknesses:

1. 6- to 24-Inch Size: 0.025 inch thick.
2. 26- to 48-Inch Size: 0.034 inch thick.

F. Accessories: Tees, elbows, increasers, draft hood connectors, termination, adjustable roof flashing, storm collar, support assembly, thimbles, firestop spacers, and fasteners; fabricated of similar materials and designs as vent-pipe straight sections.

1. Termination: Round chimney top designed to exclude 98 percent of rainfall.

2.4 FABRICATED METAL BREECHINGS

A. Breechings Less Than 24 Inches in Diameter: Galvanized-steel sheet complying with ASTM A 653/A 653M, G90 coating designation; minimum metal thickness corresponding to duct sizes in SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."

B. Breechings Less Than 24 Inches in Diameter: ASTM B 209, alloy 3003, temper H14, aluminum sheet with standard, one-side bright finish where exposed to view and with mill finish where concealed; minimum metal thickness corresponding to duct sizes in SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."

C. Breechings: Black, carbon, hot-rolled steel complying with ASTM A 569/A 569M; minimum metal thickness for corresponding sizes as indicated for the following diameters or long-side dimensions:

1. 12 Inches and Smaller: 0.0478 inch.
2. 13 to 24 Inches: 0.0598 inch.
3. 25 to 36 Inches: 0.0747 inch.
4. 37 to 60 Inches: 0.1046 inch.
5. Larger Than 60 Inches: 0.1345 inch.

D. Fabricate breechings in shop to minimize field welding. Match-mark sections for field assembly.

1. Longitudinal Seams: Welded, except longitudinal seams for breechings less than 24 inches in diameter may be grooved with pipe-lock, flat-lock, or snap-lock seams.
2. End Joints: Weld, lap, and bolt, or use companion flanges; except breechings less than 24 inches in diameter may have beaded and crimped joints.
3. Fabricate elbows with centerline radius equal to associated breeching width. Limit angular tapers to 20 degrees maximum for expanding tapers. Install accessories during fabrication to greatest extent possible.
4. Support Lug: Welded to fabricated breechings for attachment to building structure.

E. Reinforce round breechings with either flanged girth joints or angle frames as follows for corresponding diameter:

1. 30 Inches and Smaller: No reinforcement required.
2. 31 to 36 Inches: 1-1/2 by 1-1/2 by 3/16 inch, 30 inches o.c.
3. 37 to 60 Inches: 2 by 2 by 1/4 inch, 30 inches o.c.
4. Larger Than 60 Inches: 3 by 3 by 1/2 inch, 30 inches o.c.

F. Barometric Dampers: Adjustable, self-actuating draft dampers, where indicated, full size of breeching.

G. Cleanout Doors: Same weight as breeching, bolted and gasketed.

H. Thermally Actuated Vent Dampers: Tested according to AGA standards, design certified to comply with ANSI Z21.66, and sized to match draft hood collar; constructed of stainless-steel housing and brackets with four quadrants secured to brackets constructed of corrosion-resistant bimetal. Brass weights secured to quadrants to prevent vibrations and noise during high-draft conditions.

2.5 GUYING AND BRACING MATERIALS

A. Cable: Galvanized, stranded wire of the following thickness:

1. Minimum Size: 1/4 inch in diameter.
2. For ID Sizes 4 to 15 Inches: 5/16 inch in diameter.
3. For ID Sizes 18 to 24 inches: 3/8 inch in diameter.
4. For ID Sizes 27 to 30 inches: 7/16 inch in diameter.
5. For ID Sizes 33 to 36 inches: 1/2 inch in diameter.
6. For ID Sizes 39 to 48 inches: 9/16 inch in diameter.
7. For ID Sizes 51 to 60 inches: 5/8 inch in diameter.

B. Pipe: 1-1/4-inch-diameter, galvanized steel.

C. Angle Iron: Galvanized steel 1-1/2 by 1-1/2 by 3/16 inch.

PART 3 - EXECUTION

3.1 INSTALLATION OF MANUFACTURED BREECHINGS, CHIMNEYS, AND STACKS

A. Install according to manufacturer's written instructions. Locate to comply with minimum clearances from combustibles.

B. Install, support, and restrain according to requirements of seismic zone.

C. Seal between sections of positive-pressure vents according to manufacturer's written installation instructions, using sealants recommended by manufacturer.

D. Support vents at intervals recommended by the manufacturer to support weight of vent and all accessories, without exceeding loading of appliances.

1. Where maximum unsupported lengths of stack are exceeded, support chimneys as follows:

a. Guy wires.
b. Rigid pipe braces.
c. Rigid angle-iron braces.

3.2 INSTALLATION OF FABRICATED BREECHINGS

A. Install concrete inserts in formwork to support breeching independent of its appliance connection.

B. Assemble and erect fabricated breechings according to SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."

C. Install, support, and restrain according to requirements of seismic zone.

D. Align breechings at connections, with smooth internal surface and 1/8-inch misalignment tolerance.

E. Slope breechings down to appliance, with condensate drain connection at lowest point piped to nearest drain.

F. Install accessories, dampers, fans, equipment, controls, and other supports.

G. Anchor breechings to building structure with bolts, concrete inserts, steel expansion anchors, welded studs, C-clamps, or special beam clamps.

H. Support vertical stacks at 12-foot intervals by attaching to adjacent vertical structural surfaces or by direct bearing at floor penetrations and similar locations.

1. 24 by 20 Inches and Smaller: Use straps or formed angles 1-1/2 by 0.0598 inch.
2. Larger Than 24 by 20 Inches: Use steel angle brackets 1 by 1/8 inch for sizes 36 by 18 inches or smaller; 1-1/2 by 1/8 inch for larger sizes.

I. Support horizontal breechings located against structural walls and other similar adjacent vertical surfaces at 96-inch intervals for units with horizontal dimensions of 40 inches and smaller, and at 48-inch intervals for larger breechings.

1. Where Width Is Less Than Height: With straps 1-1/2 by 0.0598 inch.
2. Where Width Is More Than Height: With shelf-type fabricated angle brackets; 1 by 1/8 inch for widths 18 inches and smaller; 1-1/2 by 1/8 inch for larger widths.

J. Support horizontal rectangular breechings from overhead structure with bolted hangers at 120-inch intervals for unit widths 60 inches and smaller, and 96-inch intervals for larger breechings.

1. Breechings 60 Inches and Smaller in Width: Straps 1 by 0.0598 inch.
2. Breechings 61 to 96 Inches in Width: Straps 1-1/2 by 0.1046 inch.

K. Trapeze Hangers: Support breechings with horizontal angles and vertical supports according to the following long-side dimensions:

1. 30-Inch and Smaller Size: 1-by-1/8-inch angle, with 1-by-0.0478-inch-or 1/4-inch-diameter hangers.
2. 31- to 60-Inch Size: 1-1/2-by-1/8-inch angle, with 1-1/2-by-0.0598-inch-or 3/8-inch-diameter hangers.
3. 61- to 84-Inch Size: 2-by-1/8-inch angle, with 1-1/2-by-0.0747-inch-or 1/2-inch-diameter hangers.

4. Larger Than 84-Inch Size: 2-by-1/4-inch angle, with 5/8-inch-diameter hangers, unless otherwise indicated.

L. Support horizontal round breechings with girth strap and strap hanger (of same size). Install pair of strap hangers bolted to opposite sides of angle reinforcing rings or flanged joints. Support breechings at 120-inch intervals with hangers as follows for corresponding diameters:

1. 30 Inch and Smaller Diameter: Strap hangers 1 by 0.0598 inch.
2. 31- to 50-Inch Diameter: Strap hangers 1-1/2 by 0.0598 inch.
3. 51- to 84-Inch Diameter: Pairs of strap hangers 1-1/2 by 0.0598 inch.

3.3 INSTALLATION OF DAMPERS

A. Install barometric and thermostatically operated dampers according to manufacturer's written instructions. Locate as close to draft hood collar as possible.

3.4 INSTALLATION OF FANS

A. Install fans according to manufacturer's written instructions.

B. Secure fans to appliances, breechings, or stacks with hardware matching connected materials.

C. Install units with clearances for service and maintenance.

3.5 CLEANING

A. After completing system installation, including terminals, inspect exposed finishes. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.

B. Clean breechings internally, during and on completion of installation, to remove dust and debris. Clean external surfaces to remove welding slag and mill film. Grind welds smooth.

C. Provide temporary closures at ends of breechings and chimneys that are not completed or connected to equipment.

3.6 COMMISSIONING

A. Engage a factory-authorized service representative to perform startup service for fans.

B. Verify that fans are installed and connected according to the Contract Documents.

C. Complete installation and startup checks according to manufacturer's written instructions, and confirm fan interlocks.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain fans as specified below:

1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining fans.

2. Review data in maintenance manuals. Refer to Division 1 Section "Contract Closeout."
3. Review data in maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data."
4. Schedule training with Owner, through Architect, with at least seven days' advance notice.

END OF SECTION

SECTION 15900 - DIRECT DIGITAL CONTROL SYSTEM FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Scope: Provide labor, material, equipment, related services, and supervision required, including, but not limited to, manufacturing, fabrication, configuration and installation for complete building automation system per bid documents(also identified as BMS, Direct Digital Control System For HVAC) including all necessary hardware and all operating and applications software as required for the complete performance of the work, as indicated and specified herein.

B. Related Sections: Related sections include, but shall not be limited to, the following:

1. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
2. Applicable general requirements for electrical Work specified within Divisions 15, 16 Specification Sections apply to this Section.

C. Network level components of the system – workstations, servers, etc. shall communicate using the BACnet IP network protocol, as defined by ASHRAE Standard 135-2004. No gateways shall be used for communication to controllers furnished under this section.

D. At a minimum, provide controls for the following:

1. See mechanical plans and sequence of operations.

E. Except as otherwise noted, the control system shall consist of all necessary Ethernet Network Controllers, Standalone Digital Control Units, Room Controllers, workstations, software, sensors, transducers, relays, valves, dampers, damper operators, control panels, and other accessory equipment, along with a complete system of electrical interlocking wiring to fill the intent of the specification and provide for a complete and operable system. Except as otherwise specified, provide operators for equipment such as dampers if the equipment manufacturer does not provide these. Coordinate requirements with the various Contractors.

F. The BAS system supplier shall review and study all HVAC drawings and the entire specification to familiarize themselves with the equipment and system operation and to verify the quantities and types of dampers, operators, alarms, etc. to be provided.

G. All interlocking wiring, wiring and installation of control devices associated with the equipment listed below shall be provided under this Contract. When the BAS system is fully installed and operational, the BAS system supplier and representatives of the Owner will review and check out the system – see System Acceptance and Testing section of this document. At that time, the BAS system supplier shall demonstrate the operation of the system and prove that it complies with the intent of the drawings and specifications.

H. Provide services and manpower necessary for commissioning of the system in coordination with the Owner’s representative and the commissioning agent.

All work performed under this section of the specifications will comply with all governing codes, laws and governing bodies. If the specifications are in conflict with governing codes, the Contractor, with guidance from the owner, shall submit a proposal with appropriate modifications to the project to meet code restrictions. If this specification exceed governing code requirements, the specification will govern. The Contractor shall obtain and pay for all necessary construction permits and licenses.

1.2 REFERENCES

A. General, Code Compliance: The code listed below form a part of this Specification to the extent referenced. The codes are referred to in the text by the basic designation only. The edition/revision of the referenced code shall be the latest date as of the date of the Contract Documents, unless otherwise specified.

1. Provide BAS components and ancillary equipment, which are UL-916 listed and labeled.
2. All equipment or piping used in conditioned air streams, spaces or return air plenums shall comply with NFPA 90A Flame/Smoke/Fuel contribution rating of 25/50/0 and all applicable building codes or requirements.
3. All wiring shall conform to the National Electrical Code.
4. All smoke dampers shall be rated in accordance with UL 555S.
5. Comply with FCC rules, Part 15 regarding Class A radiation for computing devices and low power communication equipment operating in commercial environments.
6. Comply with FCC, Part 68 rules for telephone modems and data sets.

1.3 DEFINITIONS

A. Unless specifically defined within the Contract Documents, the words or acronyms contained within this specification shall be as defined within, or by the references listed within this specification, the Contract Documents, or, if not listed by either, by common industry practice.

1. Standard

a. ASHRAE: American Society Heating, Refrigeration, Air Conditioning Engineers
b. AHU: Air Handling Unit
c. BACnet: Building Automation Controls Network
d. BMS: Building Management System
e. DDC: Direct Digital Control
f. EIA: Electronic Industries Alliance
g. GUI: Graphical User Interface
h. HVAC: Heating, Ventilation, and Air Conditioning
i. IEEE: Institute Electrical Electronic Engineers
j. MER: Mechanical Equipment Room
k. PID: Proportional, Integral, Derivative
l. VAV: Variable Air Volume Box

2. Communications and protocols

a. ARP: Address Resolution Protocol
b. BACnet: Building Automation and Control Networks
c. CORBA: Common Object Request Broker Architecture
d. CSMA/CD: Carrier Sense Multiple Access/Collision Detect

e. DDE: Dynamic Data Exchange
f. FTP: File Transfer Protocol
g. FTT: Free Topology Transceivers
h. HTTP: Hyper Text Transfer Protocol
i. IIOP: Internet Inter-ORB Protocol
j. IP: Internet Protocol
k. LAN: Local Area Network
l. LON: Echelon Communication – Local Operating Network
m. MS/TP: Master Slave Token Passing
n. OBIX: Open Building Information Exchange
o. ODBC: Open Database Connectivity
p. ORB: Object Request Broker
q. SNVT: Standard Network Variables Types
r. SQL: Structured Query Language
s. UDP: User Datagram Protocol
t. XML: eXtensible Markup Language

3. Controllers

a. ASD: Application Specific Device
b. AAC: Advanced Application Controller
c. ASC: Application Specific Controller
d. CAC: Custom Application Controller
e. DCU: Distributed Control Unit
f. HRC: Hotel Room Controller
g. LCM: Local Control Module
h. MC: MicroControllers
i. MPC: Multi-purpose Controller
j. NSC: Network Server Controller
k. PEM: Package Equipment Module
l. PPC: Programmable Process Controller
m. RC: Room controller
n. RPC: Room Purpose Controller
o. SDCU: Standalone Digital Control Units
p. SLC: Supervisory Logic Controller
q. UEC: Unitary Equipment Controller
r. VAVDDC: Variable Air Volume Direct Digital Controller

4. Tools and Software

a. AFDD: Automated Fault Detection and Diagnostic
b. APEO: Automated Predictive Energy Optimization
c. DR: Demand Response
d. CCDT: Configuration, Commissioning and Diagnostic Tool
e. BPES: BACnet Portable Engineering Station
f. LPES: LON Portable Engineering Station
g. POT: Portable Operator’s Terminal
h. PEMS: Power and Energy Management Software
i. MTBF: Mean Time Between Failure

1.4 SYSTEM DESCRIPTION

A. In accordance to the scope of work, the system shall also provide a graphical, web-based, operator interface that allows for instant access to any system through a standard browser. The contractor must provide PC-based programming workstations, operator workstations and microcomputer controllers of modular design providing distributed processing capability, and allowing future expansion of both input/output points and processing/control functions.

B. For this project, the system shall consist of the following components:

1. Administration and Programming Workstation(s): The BAS system supplier shall include Operation software and architecture as described in Part 2 of the specification. These workstations must be running the standard workstation software developed and tested by the manufacturer of the network server controllers and the standalone controllers. No third party front-end workstation software will be acceptable. Workstations must conform to the B-OWS BACnet device profile.
2. Web-Based Operator Workstations: The BAS system supplier shall furnish licenses for web connection to the BAS system. Web-based users shall have access to all system points and graphics, shall be able to receive and acknowledge alarms, and shall be able to control setpoints and other parameters. All engineering work, such as trends, reports, graphics, etc. that are accomplished from the WorkStation shall be available for viewing through the web browser interface without additional changes. The web-based interface must conform to the B-OWS BACnet device profile. There will be no need for any additional computer based hardware to support the web-based user interface.
3. Ethernet-based Network Router and/or Network Server Controller(s): The BAS system supplier shall furnish needed quantity of Ethernet-based Network Server Controllers as described in Part 2 of the specification. These controllers will connect directly to the Operator Workstation over Ethernet at a minimum of 100mbps, and provide communication to the Standalone Digital Control Units and/or other Input/Output Modules. Network Server Controllers shall conform to BACnet device profile B-BC. Network controllers that utilize RS232 serial communications or ARCNET to communicate with the workstations will not be accepted. Network Controllers shall be tested and certified by the BACnet Testing Laboratory (BTL) as BACnet Building Controllers (B-BC).
4. Standalone Digital Control Units (SDCUs): Provide the necessary quantity and types of SDCUs to meet the requirements of the project for mechanical equipment control including air handlers, central plant control, and terminal unit control. Each SDCU will operate completely standalone, containing all of the I/O and programs to control its associated equipment. Each BACnet protocol SDCU shall conform to the BACnet device profile B-AAC. BACnet SDCUs shall be tested and certified by the BACnet Testing Laboratory (BTL) as BACnet Advanced Application Controllers (B-AAC).

C. The Local Area Network (LAN) shall be either a 10 or 100 Mpbs Ethernet network supporting BACnet, Modbus, XML and HTTPS for maximum flexibility for integration of building data with enterprise information systems and providing support for multiple Network Server Controllers (NSCs), user workstations and a local host computer system.

D. The Enterprise Ethernet (IEEE 802.3) LAN shall utilize Carrier Sense Multiple/Access/Collision Detect (CSMA/CD), Address Resolution Protocol (ARP) and User Datagram Protocol (UDP) operating at 10 or 100 Mbps.

E. The system shall enable an open architecture that utilizes EIA standard 709.1, the LonTalk™ protocol and/or ANSI / ASHRAE™ Standard 135-2004, BACnet functionality to assure interoperability between all system components. Native support for the LonTalk™ protocol and the ANSI / ASHRAE™ Standard 135-2004, BACnet protocol are required to assure that the project is fully supported by the HVAC open protocols to reduce future building maintenance, upgrade, and expansion costs.

F. The system shall enable an architecture that utilizes a MS/TP selectable 9.6-76.8 KBaud protocol, as a common communication protocol between controllers and integral ANSI / ASHRAE™ Standard 135-2004, BACnet functionality to assure interoperability between all system components. The AAC shall be capable of communicating as a MS/TP device or as a BACnet IP device communicating at 10/100 Mbps on a TCP/IP trunk. The ANSI / ASHRAE™ Standard 135-2004, BACnet protocol is required to assure that the project is fully supported by the leading HVAC open protocol to reduce future building maintenance, upgrade, and expansion costs.

G. LonTalk™ packets may be encapsulated into TCP/IP messages to take advantage of existing infrastructure or to increase network bandwidth where necessary or desired.

1. Any such encapsulation of the LonTalk™ protocol into IP datagrams shall conform to existing LonMark™ guide functionality lines for such encapsulation and shall be based on industry standard protocols.
2. The products used in constructing the BMS shall be LonMark™ compliant.
3. In those instances, in which Lon-Mark™ devices are not available, the BMS system supplier shall provide device resource files and external interface definitions for LonMark devices.

H. The software tools required for network management of the LonTalk™ protocol and the ANSI / ASHRAE™ Standard 135-2004, BACnet protocol must be provided with the system. Drawings are diagrammatic only. Equipment and labor not specifically referred to herein or on the plans and are required to meet the functional intent, shall be provided without additional cost to the Owner. BACnet clients shall comply with the BACnet Operator Workstation (B-OWS) device profile; with the ability to support data read and write functionality. Physical connection of BACnet devices shall be via Ethernet IP or MS/TP. Physical connection of LonWorks devices shall be via Ethernet IP or FTT-10A.

I. The system shall provide support for Modbus TCP and RTU protocols natively, and not require the use of gateways.

J. Complete temperature control system to be DDC with electronic sensors and electronic/electric actuation of Mechanical Equipment Room (MER) valves and dampers and electronic actuation of terminal equipment valves and actuators as specified herein. The BMS is intended to seamlessly connect devices throughout the building regardless of subsystem type, i.e. variable frequency drives, low voltage lighting systems, electrical circuit breakers, power metering and card access should easily coexist on the same network channel.

1. The supplied system must incorporate the ability to access all data using HTML5 enabled browsers without requiring proprietary operator interface and configuration programs. The system shall not require JAVA to be enabled in the browser.
2. Data shall reside on a supplier-installed server for all database access.

3. A hierarchical topology is required to assure reasonable system response times and to manage the flow and sharing of data without unduly burdening the customer’s internal Intranet network.

K. All work described in this section shall be installed, wired, circuit tested and calibrated by factory certified technicians qualified for this work and in the regular employment of the approved manufacturer's local field office. The approved manufacturer's local field office shall have a minimum of 3 years of installation experience with the manufacturer and shall provide documentation in the bid and submittal package verifying longevity of the installing company's relationship with the manufacturer when requested. Supervision, hardware and software engineering, calibration and checkout of the system shall be by the employees of the approved manufacturer's local field office and shall not be subcontracted. The control contractor shall have an in place support facility within 100 miles of the site with factory certified technicians and engineers, spare parts inventory and all necessary test and diagnostic equipment for the installed system, and the control contractor shall have 24 hours/day, 7 days/week emergency service available.

L. Provide the Commissioning, configuration and diagnostic tool (CCDT), color display personnel computer, software, and interfaces to provide uploading/downloading of High Point Count Controllers (AAC), Unitary Equipment Controllers (UEC) and VAV controllers (VAVDDC), monitoring all BACnet objects, monitoring overrides of all controller physical input/output points, and editing of controller resident time schedules.

M. The BMS system shall be a component of an Intelligent Building Management System (iBMS).

1. The iBMS shall integrate the Division 15 and Division 16 systems to perform automatic load shedding.

1.5 SUBMITTALS

A. General: Submittals shall be in accordance with the requirements of Section 01 33 00 Submittals and Division 15 Mechanical, in addition to those specified herein.

1. All shop drawings shall be prepared in Visio Professional or AutoCAD software. In addition to the drawings, the Contractor shall furnish a CD containing the identical information. Drawings shall be B size or larger.
2. Shop drawings shall include a riser diagram depicting locations of all controllers and workstations, with associated network wiring. Also included shall be individual schematics of each mechanical system showing all connected points with reference to their associated controller. Typicals will be allowed where appropriate.
3. Submittal data shall contain manufacturer's data on all hardware and software products required by the specification. Valve, damper and air flow station schedules shall indicate size, configuration, capacity and location of all equipment.
4. Software submittals shall contain narrative descriptions of sequences of operation, program listings, point lists, and a complete description of the graphics, reports, alarms and configuration to be furnished with the workstation software. Information shall be bound or in a three ring binder with an index and tabs. Diagrams shall be on 11” by 17” foldouts.If color has been used to differentiate information, the printed copies shall be in color.

5. Submit five (5) copies of submittal data and shop drawings to the Engineer for review prior to ordering or fabrication of the equipment. The Contractor, prior to submitting, shall check all documents for accuracy.
6. The Engineer will make corrections, if required, and return to the Contractor. The Contractor will then resubmit with the corrected or additional data. This procedure shall be repeated until all corrections are made to the satisfaction of the Engineer and the submittals are fully approved.
7. The following is a list of post construction submittals that shall be updated to reflect any changes during construction and re-submitted as "As-Built".

    a. System architecture drawing.
    b. Layout drawing for each control panel
    c. Wiring diagram for individual components
    d. System flow diagram for each controlled system
    e. Instrumentation list for each controlled system
    f. Sequence of control
    g. Binding map
    h. A matrix sheet detailing all system addresses and communication settings for the following:

        1) All IP network addresses & settings
        2) All BMS device addresses & communication settings

    i. Operation and Maintenance Manuals

8. Information common to the entire system shall be provided. This shall include but not be limited to the following.

    a. Product manuals for the key software tasks.
    b. Operating the system.
    c. Administrating the system.
    d. Engineering the operator workstation.
    e. Application programming.
    f. Engineering the network.
    g. Setting up the web server.
    h. Report creation.
    i. Graphics creation.
    j. All other engineering tasks.
    k. System Architecture Diagram.
    l. List of recommended maintenance tasks associated with the system servers, operator workstations, data servers, web servers and web clients.
    m. Define the task.
    n. Recommend a frequency for the task.
    o. Reference the product manual that includes instructions on executing the task.
    p. Names, addresses, and telephone numbers of installing contractors and service representatives for equipment and control systems.
    q. Licenses, guarantees, and warranty documents for equipment and systems.
    r. Submit one copy for each building, plus two extra copies.

9. Information common to the systems in a single building shall be provided.

    a. System architecture diagram for components within the building annotated with specific location information.
    b. As-built drawing for each control panel.
    c. As-built wiring design diagram for all components.
    d. Installation design details for each I/O device.
    e. As-built system flow diagram for each system.
    f. Sequence of control for each system.
    g. Binding map for the building.
    h. Product data sheet for each component.
    i. Installation data sheet for each component.
    j. Submit two copies for each building and two extra copies.

10. Software shall be provided:

    a. Submit a copy of all software installed on the servers and workstations.
    b. Submit all licensing information for all software installed on the servers and workstations.
    c. Submit a copy of all software used to execute the project even if the software was not installed on the servers and workstations.
    d. Submit all licensing information for all of the software used to execute the project.
    e. All software revisions shall be as installed at the time of the system acceptance.
    f. Firmware Files
    g. Submit a copy of all firmware files that were downloaded to or pre-installed on any devices installed as part of this project.
    h. This does not apply to firmware that is permanently burned on a chip at the factory and can only be replaced by replacing the chip.
    i. Submit a copy of all application files that were created during the execution of the project.
    j. Submit a copy of all graphic page files created during the execution of the project.

1.6 QUALITY ASSURANCE

A. All bidders must be building automation contractors in the business of installing direct digital control building automation systems for a minimum of 5 years.

    1. The Building Management System contractor shall have a full service facility within 50 miles of the project that is staffed with engineers trained and certified by the manufacturer in the configuration, programming and service of the automation system. The contractor’s technicians shall be fully capable of providing instructions and routine emergency maintenance service on all system components.

B. The following are the only acceptable bidders:

    1. Approved Bidder:
    Schneider Electric IP controllers installed by Grand Valley Automation (GVA)only
    NOTE: This controls scope will be an extension of the GVA existing DDC system

Each point in the system shall be tested for both hardware and software functionality. In addition, each mechanical and electrical system under control of the BAS will be tested against the appropriate sequence of operation specified herein. Successful completion of the system test shall constitute the beginning of the warranty period. A written report will be submitted to the owner indicating that the installed system functions in accordance with the plans and specifications.

C. The BAS system supplier shall commission and set in operating condition all major equipment and systems, such as the chilled water, hot water and all air handling systems, in the presence of the equipment manufacturer's representatives, as applicable, and the Owner and Architect's representatives. If the vendor is providing an AFDD/CC system, use of the analytics shall be used to help commission the system.

D. The BAS system supplier shall provide a technician for 40 hours manpower and engineering services required to assist the HVAC Contractor and Balancing Contractor in testing, adjusting, and balancing all systems in the building. The BAS system supplier shall coordinate all requirements to provide a complete air balance with the Balancing Contractor and shall include all labor and materials in his contract.

E. Startup Testing shall be performed for each task on the startup test checklist, which shall be initialed by the technician and dated upon test was completion along with any recorded data such as voltages, offsets or tuning parameters. Any deviations from the submitted installation plan shall also be recorded.

F. Required elements of the startup testing include:

1. Measurement of voltage sources, primary and secondary
2. Verification of proper controller power wiring.
3. Verification of component inventory when compared to the submittals.
4. Verification of labeling on components and wiring.
5. Verification of connection integrity and quality (loose strands and tight connections).
6. Verification of bus topology, grounding of shields and installation of termination devices.
7. Verification of point checkout.
8. Each I/O device is landed per the submittals and functions per the sequence of control.
9. Analog sensors are properly scaled and a value is reported
10. Binary sensors have the correct normal position and the state is correctly reported.
11. Analog outputs have the correct normal position and move full stroke when so commanded.
12. Binary outputs have the correct normal state and respond appropriately to energize/de-energize commands.
13. Documentation of analog sensor calibration (measured value, reported value and calculated offset).
14. Documentation of Loop tuning (sample rate, gain and integral time constant).

G. A performance verification test shall also be completed for the operator interaction with the system. Test elements shall be written to require the verification of all operator interaction tasks including, but not limited to the following.

1. Graphics navigation.
2. Trend data collection and presentation.
3. Alarm handling, acknowledgement and routing.

4. Time schedule editing.
5. Application parameter adjustment.
6. Manual control.
7. Report execution.
8. Automatic backups.
9. Web Client access.

H. A Startup Testing Report and a Performance Verification Testing Report shall be provided upon test completion. Controls contractor to carry a min of 40 hours for this testing.

1.7 COORDINATION

A. Coordinate location of thermostats, humidistats, and other exposed control sensors with plans and room details before installation.

B. Coordinate equipment from other divisions including "Intrusion Detection," "Lighting Controls," "Motor Control Centers," "Panel boards," and "Fire Alarm" to achieve compatibility with equipment that interfaces with those systems.

C. Coordinate supply of conditioned electrical circuits for control units and operator workstation.

D. Coordinate location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3 Section "Cast-in-Place Concrete".

E. Coordinate with the Owner's IT department on locations for NSC's, Ethernet communication cabling and TCP/IP addresses.

1.8 OWNERSHIP

A. The Owner shall retain licenses to software for this project.

B. The Owner shall sign a copy of the manufacturer's standard software and firmware licensing agreement as a condition off this contractor. Such license shall grant use of all programs and application software to the Owner as defined by the manufacturer's license agreement, but shall protect the manufacturer's rights to disclosure of Trade Secrets contained within such software.

C. The licensing agreement shall not preclude the use of the software by individuals under contract to the owner for commissioning, servicing or altering the system in the future. Use of the software by individuals under contract to the owner shall be restricted to use on the owner's computers and only for the purpose of commissioning, servicing, or altering the installed system.

D. All project developed software, files and documentation shall become the property of the Owner. These include but are not limited to:

1. Server and workstation software
2. Application programming tools
3. Configuration tools
4. Network diagnostic tools
5. Addressing tools

6. Application files
7. Configuration files
8. Graphic files
9. Report files
10. Graphic symbol libraries
11. All documentation

1.9 WARRANTY

A. All components, system software, and parts furnished and installed by the BMS system supplier shall be guaranteed against defects in materials and workmanship for 1 year of substantial completion. Labor to repair, reprogram, or replace these components shall be furnished by the BMS system supplier at no charge during normal working hours during the warranty period. Materials furnished but not installed by the BMS system supplier shall be covered to the extent of the product only. Installation labor shall be the responsibility of the trade contractor performing the installation. All corrective software modifications made during warranty periods shall be updated on all user documentation and on user and manufacturer archived software disks. The Contractor shall respond to the owner's request for warranty service within 24 standard working hours.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis of Design Product: Subject to compliance with requirements, provide products by one of the following pre-qualified manufacturers:

1. Electric Components

a. Schneider-Electric Field Devices

2. Electronic Components

a. Schneider-Electric Field Devices

3. Direct Digital Control Systems Field Controller Devices:

a. Schneider Electric EcoStruxure Building BACnet IP series installed by approved manufacturer's local field office or authorized distributor.
b. Or approved equal.

2.2 OPEN, INTEROPERABLE SYSTEM ARCHITECTURE

A. General

1. The Building Automation System (BAS) shall consist of Network Server/Controllers (NSCs), a family of Standalone Digital Control Units (SDCUs), Administration and Programming Workstations (APWs), and Web-based Operator Workstations (WOWs). The BAS shall provide control, alarm detection, scheduling, reporting and information management for the entire facility, and Wide Area Network (WAN) if applicable.

2. An Enterprise Level BAS shall consist of an Enterprise Server, which enables multiple NSCs (including all graphics, alarms, schedules, trends, programming, and configuration) to be accessible from a single Workstation simultaneously for operations and engineering tasks.
3. The Enterprise Level BAS shall support built-in reporting functionality without dependency on other software.
4. The Enterprise Level BAS shall support standard accessing of data for third party reporting or analytics software.
5. The Enterprise Level BAS shall be able to host up to 250 servers, or NSCs, beneath it.
6. For Enterprise reporting capability and robust reporting capability outside of the trend chart and listing ability of the Workstation, a Reports Server shall be installed on a Microsoft Windows SQL based computer. The Reports Server can be installed on the same computer as the Enterprise Server.
7. The system shall be designed with a top-level 10/100bT Ethernet network, using the BACnet/IP, LonWorks IP, and/or Modbus TCP protocol.

B. Modbus RTU/ASCII (and J-bus), Modbus TCP, BACnet MS/TP, BACnet IP, LonTalk FTT-10A, and WebServices shall be native to the NSCs. There shall not be a need to provide multiple NSCs to support all the network protocols, nor should there be a need to supply additional software to allow all three protocols to be natively supported.

C. A sub-network of SDCUs using the BACnet IP protocol shall connect the local, stand-alone controllers with Ethernet-level Network Server Controllers/IP Routers.

D. The TCP/IP layer connects all of the buildings on a single Wide Area Network (WAN) isolated behind the campus firewall. Fixed IP addresses for connections to the campus WAN shall be used for each device that connects to the WAN.

E. The fieldbus layer shall support all of the following types of SDCUs:

1. BACnet IP SDCU requirements: The system shall consist of one or more BACnet/IP field buses managed by the Network Server Controller. The field bus layer shall consist of up to 50 IP SDCUs in daisy chain topology, or 39 if using RSTP, per layer, with a max of 5 sub networks in daisy chain for a total of 250 SDCUs or 6 sub networks in RSTP for a total of 234 SDCUs. The field bus layer shall consist ONLY of BACnet IP SDCUs. No other protocols, including BACnet MS/TP, shall be acceptable.

F. The BAS shall be capable of being segmented, through software, into multiple local area networks (LANs) distributed over a wide area network (WAN). Workstations can manage a single LAN (or building), and/or the entire system with all portions of that LAN maintaining its own, current database.

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

H. System Expansion

1. The BAS system shall be scalable and expandable at all levels of the system using the same software interface, and the same TCP/IP level and fieldbus level controllers. Systems that require replacement of either the workstation software or field controllers in order to expand the system shall not be acceptable.
2. Web-based operation shall be supported directly by the NSCs and require no additional software.
3. The system shall be capable of using graphical and/or line application programming language for the Network Server Controllers.
4. The system shall be able to operate normally and without restriction at multiple software version levels with the only requirement that each element of the hierarchy be at least as new a version as the newest version in the level below it. In other words, Enterprise Servers will be able to manage NSCs of different version provided that the Enterprise Server was the same or more recent version than the most recent NSC version.

I. All Network Server Controllers must natively support the BACnet IP, BACnet MS/TP, LonWorks FTT-10, Modbus TCP, Modbus RTU (RS-485 and RS-232), and Modbus ASCII protocols.

2.3 OPERATOR WORKSTATION REQUIREMENTS

A. General

1. The operator workstation portion of the BAS shall consist of one or more full-powered configuration and programming workstations, and one or more web-based operator workstations. For this project provide a minimum of 3 concurrent client licenses at the enterprise level. Client licenses are licenses that can be used for variable designations of the users choosing; i.e. operator, engineering, or web capabilities.
2. The programming and configuration workstation software shall allow any user with adequate permission to create and/or modify any or all parts of the NSC and/or Enterprise Server database.
3. At the NSC level, there shall be no cap on concurrent web-based workstations (webstations) other than what the CPU capacity can support.
4. All configuration workstations shall be personal computers operating under the Microsoft Windows operating system. The application software shall be capable of communication to all Network Server Controllers and shall feature high-resolution color graphics, alarming, trend charting. It shall be user configurable for all data collection and data presentation functions.
5. A minimum of 1 physical Workstation shall be allowed on the Ethernet network. In this client/server configuration, any changes or additions made from one workstation will automatically appear on all other workstations since the changes are accomplished to the databases within the NSC. Systems with a central database will not be acceptable.

B. Enterprise Central, Enterprise Server, Administration/Programming Workstation, and Webstation Requirements

1. The Enterprise Central shall consist of the following:

a. Processor

1) Minimum: Intel Core i5 @ 3.0 GHz or equivalent
2) Recommended: Intel Core i5 @ 4.0 GHz or better

b. Memory

1) Minimum:6GB
2) Recommended:12GB or higher

c. Operating systems:

1) Microsoft Windows 10 64-bit
2) Microsoft Windows Server 2012 R2 64-bit
3) Microsoft Windows Server 2016
4) Microsoft Windows Server 2019

d. 10/100MBPS Ethernet NIC
e. Storage

1) Minimum: 1TB
2) Recommended: 4TB
3) Solid State Drive recommended

f. Required additional software:

1) Microsoft .Net 4.7.2 and later

g. License agreement for all applicable software
h. External log storage option

1) PostgreSQL 11.0 and later
2) TimescaleDB 1.2 and later

2. The Enterprise Server shall consist of the following:

a. Processor

1) Minimum: Intel Core i5 @ 2.0 GHz or equivalent
2) Recommended: Intel Core i5 @ 3.0 GHz or better

b. Memory

1) Minimum: 4GB
2) Recommended: 8GB or higher

c. Operating systems:

1) Microsoft Windows 7 64-bit
2) Microsoft Windows 10 64-bit
3) Microsoft Windows Server 2012 R2 64-bit
4) Microsoft Windows Server 2016
5) Microsoft Windows Server 2019

d. 10/100MBPS Ethernet NIC
e. Storage

1) Minimum: 100GB
2) Recommended: 1TB
3) Solid State Drive recommended

f. Required additional software:

1) Microsoft .Net 4.7.2 and later

g. License agreement for all applicable software
h. External log storage option

1) PostgreSQL 11.0 and later
2) TimescaleDB 1.2 and later

3. The Workstation shall consist of the following:

a. Processor

1) Minimum: Intel Core i5 @ 2.0 GHz or equivalent
2) Recommended: Intel Core i5 @ 3.0 GHz or better

b. Memory

1) Minimum: 4GB
2) Recommended: 8GB or higher

c. Operating systems:

1) Microsoft Windows 10 64-bit
2) Microsoft Windows Server 2012 R2 64-bit
3) Microsoft Windows Server 2016
4) Microsoft Windows Server 2019

d. 10/100MBPS Ethernet NIC
e. Storage

1) Minimum: 20GB
2) Recommended: 1TB
3) Solid State Drive recommended

f. Required additional software:

1) Microsoft .Net 4.7.2 and later

g. License agreement for all applicable software

4. Web-Based Operator PC Requirements

    a. Any user on the network can access the system, using the following software:
    b. Minimum:

        1) Google Chrome 61 or higher
        2) Mozilla Firefox 60 or higher
        3) Microsoft Edge (EdgeHTML) 16 or higher
        4) Safari 11.1 or higher

    c. Recommended:

        1) Google Chrome 71 or higher
        2) Mozilla Firefox 64 or higher
        3) Microsoft Edge (EdgeHTML) 17 or higher
        4) Safari 11.4 or higher

C. General Administration and Programming Workstation Software

1. System architecture shall be truly client server in that the Workstation shall operate as the client while the NSCs shall operate as the servers. The client is responsible for the data presentation and validation of inputs while the server is responsible for data gathering and delivery.
2. The workstation functions shall include monitoring and programming of all DDC controllers. Monitoring consists of alarming, reporting, graphic displays, long term data storage, automatic data collection, and operator-initiated control actions such as schedule and setpoint adjustments.
3. Programming of SDCUs shall be capable of being done either off-line or on-line from any operator workstation. All information will be available in graphic or text displays stored at the NSC. Graphic displays will feature animation effects to enhance the presentation of the data, to alert operators of problems, and to facilitate location of information throughout the DDC system. All operator functions shall be selectable through a mouse.

D. User Interface:

1. The BAS workstation software shall allow the creation of a custom, browser-style interface linked to the user when logging into any workstation. Additionally, it shall be possible to create customized workspaces that can be assigned to user groups. This interface shall support the creation of “hot-spots” that the user may link to view/edit any object in the system or run any object editor or configuration tool contained in the software. Furthermore, this interface must be able to be configured to become a user’s “PC Desktop” – with all the links that a user needs to run other applications. This, along with the Windows user security capabilities, will enable a system administrator to setup workstation accounts that not only limit the capabilities of the user within the BAS software, but may also limit what a user can do on the PC and/or LAN/WAN. This might be used to ensure, for example, that the user of an alarm monitoring workstation is unable to shutdown the active alarm viewer and/or unable to load software onto the PC.
2. System shall be able to automatically switch between displayed metric vs. imperial units based on the workstation/webstations localization.

3. The BMS workstation/webstations shall be capable of multiple language display, including English, Spanish, German, French, Japanese, Italian, Finnish, Portuguese, Swedish, Russian, and traditional and simplified Chinese.The multiple languages shall not require additional add on software from the standard workstation installer and shall be selectable within said workstation.
4. Webstations shall have the capability to automatically re-direct to an HTTPS connection to ensure more secure communications.
5. Personalized layouts and panels within workstations shall be extended to webstations to ensure consistent user experiences between the two user interfaces.
6. Webstations shall give the user the same capabilities within the graphics pages as are given within the workstation but shall be mobile responsive for use on smaller devices.
7. Servers and clients shall have the ability to be located in different time zones, which are then synchronized via the NTP server.
8. Workstation shall indicate at all times the communication status between it and the server.
9. The BMS web interface shall enable presentation mode whereby any functionality for interactivity shall be disabled.
10. The BMS web interface shall automatically detect light mode and dark mode settings in the operating system and adapt accordingly.
11. The BMS web interface shall allow override of the operating systems light/dark mode settings so that the setting can be enabled independent of the operating system's setting.
12. The BMS web interface shall automatically respond and adapt to different screen sizes and orientations from smart phone to smart televisions of any size.
13. The BMS web interface shall support slideshow functionality.
14. The BMS web interface shall support full screen mode displaying Alarm views / graphics / dashboards / Custom Reports.

E. User Access and Permissions

1. The BMS system shall allow for creation of one account per user.
2. The BMS shall support Groups where User Accounts associated with the group can inherit group permissions.
3. The BMS shall be able to specify each user account/group accessibility to each object in the system.
4. The BMS permission system shall be possible to integrate with Windows Active directory.
5. The BMS shall be able to report on the permission level across account / group for review / archiving / audit.
6. This username/password combination shall be linked to a set of capabilities within the software, set and editable only by user with system administrator privileges. The sets of capabilities shall include: edit or View only, Acknowledge alarms, Enable/disable Program and change values.
7. The system shall allow the above capabilities to be applied independently to each and every class of object in the system.
8. The BMS shall support integration with Windows Active Directory for user log on credentials.
9. The BMS shall support configurable reminder for "Days until password expires".
10. The BMS shall support configurable password policy across:

    a. Minimum number of characters
    b. Minimum number of lowercase characters

c. Minimum number of numeric characters
d. Minimum number of special characters
e. Number of consecutive unique passwords before reuse
f. No more than three repeating identical characters

11. The BMS user account management shall support password policy with the following components:

    a. Mandatory change of password at first logon with default credentials
    b. Disabling of all imported user accounts by default
    c. Custom password complexity rules and its enforcement
    d. Custom password reuse and its enforcement
    e. Configurable black listing of passwords to limit the use of common known passwords (e.g. password)
    f. Password aging rules

12. The BMS shall be capable of enabling an anonymous access (guest account) to previously engineered views such as dashboards, graphics, etc. with configurable permissions and without username or password.
13. It shall be possible to configure the BMS system so that the guest account is used by default to simplify presentation of Kiosk Mode across multiple screens
14. The BMS shall provide time configurability to logout the user and to revert to a preconfigured presentation view, such as offered by the Guest account functionality.
15. The BMS shall provide configurability in managing access and permission levels based on location, IP addresses and address ranges, Schedule and Time of day and combination thereof.

F. System Security

1. The BMS system supplier The BMS vendor shall be certified to Security Development Lifecycle process that is certified to IEC 62443-4-1 by a reputable third party independent lab.
2. The BMS system supplier shall be subjected to regular and verifiable best practice cyber security testing by the system supplier. Results of this testing shall be made available upon request prior to deployment of the system.
3. The BMS system supplier shall provide cyber security service incident escalation through help desk on a 7/24/365 basis.
4. The BMS shall support configuration for inactivity auto log-off of logged clients
5. The BMS system shall support Self-Signed Certificates, Default Certificates and/or Certification Authority (CA) certificates.
6. The BMS client communications (web access or rich client access) shall support TLS 1.2 encryption or higher
7. The BMS shall allow configuration in disabling all devices and software that support HTTP and require access via HTTPS.
8. The BMS must be able to Alarm or generate notification on failed access attempts
9. The BMS Servers shall support SNMP V3 monitoring of network performance and stack statistics for the purpose of managing denial of service attacks
10. The Integrated Control Platform shall support the feature to alarm on a predetermined period of time until the default password for each device is changed from the default factory setting.

11. The Integrated Control Platform shall support encrypted password authentication for all web services whether serving or consuming.
12. The BMS shall have the capability to use blacklisted and whitelisted IPs/MAC addresses to gate access
13. The BMS shall have the capability to differentiate, limit or enable, user access depending on Client's IP address/range (where) and time of day (when) the user is accessing the system.

G. Configuration Interface

1. The workstation software shall use a familiar Windows Explorer style interface for an operator or programmer to view and/or edit any object (controller, point, alarm, report, schedule, etc.) in the entire system. In addition, this interface shall present a "network map" of all controllers and their associated points, programs, graphics, alarms, and reports in an easy to understand structure.All object names shall be alphanumeric and use Windows long filename conventions.
2. The configuration interface shall also include support for user defined object types. These object types shall be used as building blocks for the creation of the BAS database. They shall be created form the base object types within the system input, output, string variables, setpoints, etc., alarm algorithms, alarm notification objects, reports, graphics displays, schedules, and programs. Groups of user defined object types shall be able to be set up as a predefined aggregate of subsystems and systems. The configuration interface shall support copying/pasting and exporting/importing portions of the database for additional efficiency. The system shall also maintain a link to all "child" objects created.If a user wishes to make a change to a parent object, the software shall ask the user if he/she wants to update all of the child objects with the change.

H. Color Graphic Displays

1. The system shall allow for the creation of user defined, color graphic displays for the viewing of mechanical and electrical systems, or building schematics.These graphics shall contain point information from the database including any attributes associated with the point (engineering units, etc.).In addition, operators shall be able to command equipment or change setpoints from a graphic through the use of the mouse.
2. Requirements of the color graphic subsystem include:

    a. At a minimum, the user shall have the ability to import .gif, .png, .bmp, .jpeg, .tif, and CAD generated picture files as background displays, and layering shall be possible.
    b. The system shall support HTML5 enabled graphics.
    c. It shall be possible for the user to use JavaScript to customize the behavior of each graphic.
    d. The editor shall use Scalable Vector Graphics (SVG) technology.
    e. A built-in library of animated objects such as dampers, fans, pumps, buttons, knobs, gauges, ad graphs which can be "dropped" on a graphic through the use of a software configuration "wizard". These objects shall enable operators to interact with the graphic displays in a manner that mimics their mechanical equivalents found on field installed control panels.
    f. Support for high DPI icons shall be included and automatically chosen if viewing on a high definition display such as Retina or 4K displays.

g. Using the mouse, operators shall be able to adjust setpoints, start or stop equipment, modify PID loop parameters, or change schedules.
h. Status changes or alarm conditions must be able to be highlighted by objects changing screen location, size, color, text, blinking or changing from one display to another.
i. Ability to link graphic displays through user defined objects, alarm testing, or the result of a mathematical expression.Operators must be able to change from one graphic to another by selecting an object with a mouse - no menus will be required.
j. It shall be possible to create and save graphical components and JavaScript code in reusable and transferrable, customized libraries.
k. Graphics should rescale based on whatever monitor or viewing device is being used.
l. Be able to create graphics on varying layers that can be moved and repeated.
m. Be able to create graphics within varying window panes that can be moved and/or re-referenced.For example, creating the graphical menu within a pane and referencing it on every graphics page, therefore not rebuilding thus allowing for a single spot for updates that get pushed to all the pages that reference it.
n. The ability to create re-usable cascading menus.
o. The ability to have multiple instances of a graphic and edit one instance to change all.

3. Additionally, the Graphics Editor portion of the Engineering Software shall provide the following capabilities:

a. Create and save pages.
b. Group and ungroup symbols.
c. Modify an existing symbol.
d. Modify an existing graphic page.
e. Rotate and mirror a symbol.
f. Place a symbol on a page.
g. Place analog dynamic data in decimal format on a page.
h. Place binary dynamic data using state descriptors on a page.
i. Create motion through the use of animated .gif files or JavaScript.
j. Place test mode indication on a page.
k. Place manual mode indication on a page.
l. Place links using a fixed symbol or flyover on a page.
m. Links to other graphics.
n. Links to web sites.
o. Links to notes.
p. Links to time schedules.
q. Links to any .exe file on the operator work station.
r. Links to .doc files.
s. Assign a background color.
t. Assign a foreground color.
u. Place alarm indicators on a page.
v. Change symbol/text/value color as a function of an analog variable.
w. Change a symbol/text/value color as a function of a binary state.
x. Change symbol/text/value as a function of a binary state.
y. All symbols used by Schneider Electric EcoBuilding Business in the creation of graphic pages shall be saved to a library file for use by the owner.

I. The software shall allow for the automatic collection of data and reporting from any controller or NSC. The frequency of data collection shall be user-configurable.

J. Alarm Management

1. The software shall be capable of accepting alarms directly from NSCs or controllers, or generating alarms based on evaluation of data in controllers and comparing to limits or conditional equations configured through the software.Any alarm (regardless of its origination) will be integrated into the overall alarm management system and will appear in all standard alarm reports, be available for operator acknowledgment, and have the option for displaying graphics, or reports.
2. Alarm management features shall include:

    a. A minimum of 1000 alarm notification levels at the NSC, workstation, and webstation levels.
    b. Each notification level will establish a unique set of parameters for controlling alarm display, distribution, acknowledgment, keyboard annunciation, and record keeping.
    c. At the Enterprise level the minimum number of active and viewable alarms shall be 10,000.
    d. It shall be possible for the user to sort, filter and search on any available criteria such as priority, category, origin, alarm type, etc.
    e. An active alarm viewer shall be included which can be customized for each user or user type to a hide or display any alarm attributes.
    f. It shall be possible to present alarms with configurable colors based on priority, category, origin, alarm type, etc.
    g. It shall be possible to linking files/documents/hyperlinks/navigation links/graphics link to an alarm for easy access upon occurrence
    h. Automatic logging in the database of the alarm message, point name, point value, source device, timestamp of alarm, username and time of acknowledgement, username and time of alarm silence (soft acknowledgement).
    i. Alarm notifications must support multiple distribution methods within one notification
    j. On alarm, it shall be possible to notify via email to a preconfigured list of recipients through a Simple Mail Transfer Protocol (SMTP) or secure email using Simple Mail Transfer Protocol Secure (SMTPS). No special software interfaces shall be required and no email client software must be running in order for email to be distributed. The email notification shall be able to be sent to an individual user or a user group.
    k. On alarm, it shall be possible to notify via SNMP
    l. On alarm, it shall be possible to notify via file (on disk) that would be consumable by other alarm management services
    m. An operator shall have the capability to assign an alarm to another user of the system.
    n. Individual alarms shall be able to be assigned to a user automatically via a preconfigured list of users and date/time. For example, a critical high temp alarm can be configured to be assigned to a Facilities Dept or to a Central Alarming workstation depending on time/date.
    o. Playing an audible sound on alarm initiation or return to normal.
    p. It shall be possible assigning a custom audio sound to each alarm / alarm-criteria (priority, category, origin, alarm type, etc.)

q. The active alarm viewer can be configured such that an operator must confirm that all of the steps in a check list have been accomplished prior to acknowledging the alarm.
r. The active alarm viewer shall, if filtered, show the quantity of visible and total number of alarms that are not equal to 'normal' and the quantity of disabled and hidden alarms.
s. The alarm viewer can be configured to auto hide alarms when triggered.
t. An operator shall have the capability to save and apply alarm favorites.
u. Alarms shall be configurable such that an operator must type in text in an alarm entry and/or pick from a drop-down list of user actions for certain alarms.
v. Alarms shall be configurable such that an operator must type in text in an alarm entry and/or pick from a drop-down list of causes for certain alarms. This ensures accountability (audit trail) for the response to critical alarms.
w. It shall be possible to configure user-actions via user/group permissions when responding to an alarm
x. All operator actions responding to an alarm must be audit trailed.

K. Static Paginated Reporting / Custom Reporting

1. The BMS Software and Network Servers shall support built-in native reporting capability without dependency on any external software
2. It shall be possible to generate custom reports manually, via Schedule, Alarm triggered or custom conditions (e.g. program/schedule/etc.)
3. The Custom Reporting shall have no dependency on external database
4. The Custom Reporting shall have the capability of reporting on the full range of available data, most recent to historical data.
5. It shall be possible to generate reports containing current active alarms
6. The Building Management System software shall natively be capable of producing custom repots in txt, xlxs and pdf file formats.
7. The Custom Report capability at the BMS software shall support digital signing of pdf for traceability and authenticity.

L. Dashboards

1. Dashboards shall provide rapid identification of real-time and historical trends, including energy use, operational efficiencies and critical metrics.
2. Using the Native Web Browser interface the system must allow for the selection, from a wide range of layouts and widgets (dashboard components), of items to create Dashboards
3. System must allow for dashboard view customization and selection of data points via the web browser and w/o any tools or prior training.
4. Built-in dashboards - A basic set of dashboard components shall be provided as part of the project. At a minimum, the following dashboard components functionality shall be provided for the Owner's use:

    a. Resource Utilization

        1) This is used to illustrate the comparative consumption of a resource (like energy) over a flexible time period.
        2) The information is ordered by location and multiple locations may be plotted on the same columnar chart for clear analysis and comparison.

b. Utility Performance Index

1) This enables the creation and visualization of one or more Key Performance Index (KPI) charts for comparisons of resource utilization efficiencies for multiple locations.
2) A typical use of this is in displaying a "scatter plot" of consumption (y-axis) versus consumption per unit area (x-axis).
3) For example; an "Energy" KPI can be displayed by selecting the locations of interest (e.g. all Offices on Campus), selecting the vertical axis variable as Electric Consumption (kWh) and the horizontal axis as a "normalized" metric, such as "kWh per SFt".

c. Real time Gauges

1) Gauges allow the Owner to track values such as temperature, pressure, humidity and level in real time.

d. Historical Gauges

1) Gauges allow calculation of values based on historical data; for instance presenting max/min/average temperature/pressure/humidity over a given period

e. Period over Period Comparison

1) It shall be possible to visually compare historical data (e.g. temperature, energy, etc.) across multiple overlapping time periods (hours, days, weeks, etc.)

5. Custom dashboard components –

a. Custom dashboard components shall be able to present any information from the BMS (e.g. system health data, alarms, trends, events, user access, etc.)
b. The BMS shall allow creation of customized dashboard components in to presenting meaningful information as per customer

M. Scheduling

1. From the workstation or webstation, it shall be possible to configure and download schedules for any of the controllers on the network.
2. Time of day schedules shall be in a calendar style and viewable in both a graphical and tabular view.
3. Schedules shall be programmable for a minimum of one year in advance.
4. To change the schedule for a particular day, a user shall simply select the day and make the desired modifications.
5. Additionally, from the operator webstations, each schedule will appear on the screen viewable as the entire year, monthly, week and day. A simple mouse click shall allow switching between views. It shall also be possible to scroll from one month to the next and view or alter any of the schedule times.

6. Schedules will be assigned to specific controllers and stored in their local RAM memory.Any changes made at the workstation will be automatically updated to the corresponding schedule in the controller.
7. It shall be possible to assign a lead schedule such that shadow/local schedules are updated based upon changes in the Lead.
8. It shall be possible to assign a list(s) of exception event days, dates, date ranges to a schedule.
9. It shall be possible to view combined views showing the calendar and all prioritized exemptions on one screen.
10. It should accommodate a minimum of 16 priority levels.
11. Values should be able to be controlled directly from a schedule, without the need for special program logic.

N. Programmer's Environment

1. Programming in the NSC shall be either in graphical block format or line-programming format or both.
2. Programming of the NSC shall be available offline from system prior to deployment into the field.All engineering tasks shall be possible, except, of course, the viewing of live tasks or values.
3. The programmer's environment will include access to a superset of the same programming language supported in the SDCUs.
4. NSC devices will support both script programming language as well as the graphical function block programming language. For both languages, the programmer will be able to configure application software for custom program development, and write global control programs.Both languages will have debugging capabilities in their editors.
5. It shall be possible to save custom programs as libraries for reuse throughout the system.A wizard tool shall be available for loading programs from a library file in the program editor.
6. The system shall be capable of creating ‘custom types’. These types can be created within the programming environment, graphics, or as full controller ‘templates’ that can be pushed to any other variable pertaining to it to allow for singular reference to multiple objects. This allows easing of updating/changes allowing the use to make a singular change and push to all connected instances.
7. It shall be possible to view graphical programming live and real-time from the Workstation.
8. The system shall be capable of creating ‘binding templates’ allowing the user to bind multiple points to multiple objects all at once.
9. Key terms should appear when typing (IntelliType).
10. Applications should be able to be assigned different priorities and cycle times for a prioritized execution of different function.
11. The system shall be able to create objects that allow common objects such as power meters, VFD drives, etc. to be integrated into the system with simple import actions without the need of complicated programming or configuration setups.

O. Saving/Reloading

1. The workstation software shall have an application to save and restore NSC and field controller memory files.

2. For the NSC, this application shall not be limited to saving and reloading an entire controller – it must also be able to save/reload individual objects in the controller. This allows off-line debugging of control programs, for example, and then reloading of just the modified information.

P. Audit Trail

1. The workstation software shall automatically log and timestamp every operation that a user performs at a workstation, from logging on and off a workstation to changing a point value, modifying a program, enabling/disabling an object, viewing a graphic display, running a report, modifying a schedule, etc.
2. It shall be possible to view a history of alarms, user actions, and commands for any system object individually or at least the last 5000 records of all events for the entire system from Workstation.
3. The Enterprise server shall be able to store up to 5 million events.
4. The event view shall support viewing of up to 100,000 events.
5. It shall be possible to save custom filtered views of event information that are viewable and configurable in Workstation.
6. It shall be capable to search and view all forced values within the system.

Q. Fault Tolerant Enterprise Server Operation (Top level NSC)

1. A single component failure in the system shall not cause the entire system to fail.All system users shall be informed of any detectable component failure via an alarm event.System users shall not be logged off as a result of a system failure or switchover.

R. Web-based Operator Software

1. General:

   a. Day-to-day operation of the system shall be accessible through a standard web browser interface, allowing technicians and operators to view any part of the system from anywhere on the network.
   b. The system shall be able to be accessed on site via a mobile device environment with, at a minimum, access to overwrite and view system values.
   c. Through the browser interface, operators must be able to view pre-defined groups of points, with their values updated automatically.

2. Graphic Displays

   a. The browser-based interface must share the same graphical displays as the Administration and Programming Workstations, presenting dynamic data on site layouts, floor plans, and equipment graphics. The browser’s graphics shall support commands to change setpoints, enable/disable equipment and start/stop equipment.
   b. Through the browser-based interface, operators must be able to navigate through the entire system, and change the value or status of any point in any controller. Changes are effective immediately to the controller, with a record of the change stored in the system database.
   c. System shall have out-of-the-box dashboards that enable customizable views of live data which can be public to all users or capable to make them specific to a user based on log in credentials.

d. The user shall have the ability to create custom dashboards.
e. The dashboards shall have a kiosk mode which allows for occupant level data display on monitors or tablets throughout the building.

3. Alarm Management

a. Systems requiring additional client software to be installed on a PC for viewing the webstation from that PC will not be considered.
b. Through the browser interface, a live alarm viewer identical to the alarm viewer on the Administration and Programming workstation shall be presented, if the user's password allows it. Users must be able to receive alarms, silence alarms, and acknowledge alarms through a browser. If desired, specific operator text must be able to be added to the alarm record before acknowledgement, attachments shall be viewable, and alarm checklists shall be available.

S. Groups and Schedules

1. Through the browser interface, operators must be able to view pre-defined groups of points, with their values updated automatically.
2. Through the browser interface, operators must be able to change schedules – change start and stop times, add new times to a schedule, and modify calendars.

T. User Accounts and Audit Trail

1. The same user accounts shall be used for the browser interface and for the operator workstations. Operators must not be forced to memorize multiple passwords.
2. All commands and user activity through the browser interface shall be recorded in the system's activity log, which can be later searched and retrieved by user, date, or both.

U. Web Services

1. The installed system shall be able to use web services to "consume" information within the Network Server/Controllers (NSCs) with other products and systems.Inability to perform web services within the NSCs will be unacceptable.

a. Shall be able to "consume" data into the system via SOAP and REST web services

2.4 NETWORK SERVER CONTROLLERS (NSC)

A. Network Server Controllers shall combine both network routing functions, control functions, and server functions into a single unit.

B. The BACnet NSC shall be classified as a "native" BACnet device, supporting the BACnet Network Server Controller (B-BC) profile. Controllers that support a lesser profile such as B-SA are not acceptable.NSCs shall be tested and certified by the BACnet Testing Laboratory (BTL) as BACnet Network Server Controllers (B-BC).

C. The Network Server Controller shall provide the interface between the LAN or WAN and the field control devices, and provide global supervisory control functions over the control devices connected to the NRS.

D. The NSCs shall be capable of whitelisting IPs to restrict access to a pre-defined list of hosts or devices.

E. Whitelisting of file extensions for documents shall be capable.

F. Encrypted and authenticated communication shall be configurable for non-open protocol communications using TLS 1.2.

G. The NSCs shall support Simple Network Management Protocol version 3 (SNMPv3) for monitoring of the NSCs using a Network Management Tool.

H. The NSCs shall support remote system logging for used by System Information and Event Monitoring (SIEM) software.

I. They shall also be responsible for monitoring and controlling their own HVAC equipment such as an AHU or boiler.

J. They shall also contain graphics, trends, trend charts, alarm views, and other similar presentation objects that can be served to workstations or web-based interfaces.A sufficient number of NSCs shall be supplied to fully meet the requirements of this specification and the attached point list.

K. It shall be capable of executing application control programs to provide:

1. Calendar functions
2. Scheduling
3. Trending
4. Alarm monitoring and routing
5. Time synchronization by means of an Internet site including automatic synchronization
6. Native integration of LonWorks controller data and Modbus controller data or BACnet controller data and Modbus controller data
7. Network Management functions for all LonWorks based devices

L. Hardware Specifications

1. Memory:

a. The operating system of the controller, application programs, and all other portions of the configuration database, shall be stored in non-volatile, FLASH memory. Servers/Controllers shall contain enough memory for the current application, plus required history logging, plus a minimum of 20% additional free memory.

2. Each NRC shall provide the following on-board hardware for communication:

a. Two 10/100b Ethernet for communication to Workstations, other NRCs, IP field bus controllers, other SDCUs, and onto the internet.

1) The two Ethernet ports shall support active switch and BACnet/IP communication protocols.
2) Support IPv4 addressing

3) Ethernet port 1 shall support static or DHCP client configuration for communication to Workstation or other NSCs
4) Ethernet port 2 shall support switch mode or DHCP server to set addressing of DHCP client devices
5) It shall be possible to disable Ethernet port 2
6) In DHCP server mode, the Ethernet port 2 shall support 50 BACnet/IP field controllers in daisy chain configuration directly from the port
7) Each NSC shall be able to support a total of 250 IP SDCUs in daisy chain configuration (5 sub networks via switch)
8) If using RSTP (Rapid Spanning Tree Protocol) with a managed switch (with IEEE 802.1W or IEEE 802.1Q-2014 support), Ethernet port 2 shall support up to 39 devices
9) Each NSC shall be able to support a total of 234 IP SDCUs in RSTP configuration (6 sub networks via managed switch)
10) Where a switch is needed, use a Cisco 9000 Catalyst or IE switch, EtherWAN EX63402-01B, or other equal and approved equivalent.

b. Two RS-485 ports for communication to BACnet MSTP bus or serial Modbus (software configurable)
c. One TP/FT port for communication to LonWorks devices.
d. One device USB port
e. One host USB port

3. The NSC shall conform to a small footprint no larger than 3.94W x 4.92H x 2.95D in.

M. Modular Expandability:

1. The system shall employ a modular I/O design to allow expansion. Input and output capacity is to be provided through plug-in modules of various types. It shall be possible to combine I/O modules as desired to meet the I/O requirements for individual control applications.
2. One shall be able to “hot-change” (hot-swap) the I/O modules preserving the system on-line without any intervention on the software; addressing and configuration shall be automatic.
3. If for any reason the backplane of the modular I/O system were to fail, I/O module addresses will be protected.

N. Hardware Override Switches:

1. All digital outputs shall, optionally, include three position manual override switches to allow selection of the ON, OFF, or AUTO output state. These switches shall be built into the unit and shall provide feedback to the controller so that the position of the override switch can be obtained through software.In addition each analog output shall be equipped with an override potentiometer to allow manual adjustment of the analog output signal over its full range, when the 3 position manual override switch is placed in the ON position.

O. Universal Input Temperatures

1. All universal inputs directly connected to the NSC via modular expansion shall be capable of using the following thermistors for use in the system without any external converters needed.

   a. 10 kohm Type I (Continuum)
   b. 10 kohm Type II (I/NET)
   c. 10 kohm Type III (Satchwell)
   d. 10 kohm Type IV (FD)
   e. Linearized 10 kohm Type V (FD w/11k shunt)
   f. Linearized 10 kohm (Satchwell)
   g. 1.8 kohm (Xenta)
   h. 1 kohm (Balco)
   i. 20 kohm (Honeywell)
   j. 2.2 kohm (Johnson)

2. In addition to the above, the system shall be capable of using the below RTD sensors, however it is not required that all universal inputs be compatible with them.

   a. PT100 (Siemens)
   b. PT1000 (Sauter)
   c. Ni1000 (Danfoss)

P. Local Status Indicator Lamps:

1. The NSC shall provide as a minimum LED indication of CPU status, Ethernet LAN status, and field bus status.For each input or output, provide LED indication of the value of the point (On/Off).The LED indication shall support software configuration to set whether the illumination of the LED corresponds to On or Off or whether the color when illuminated is Red or Green.

Q. Real Time Clock (RTC):

1. Each NSC shall include a real time clock, accurate to 10 seconds per day.The RTC shall provide the following: time of day, day, month, year, and day of week. Each NSC will allow for its own UTC offset, depending upon the time zone. When the time zone is set, the NSC will also store the appropriate times for daylight savings time.
2. The RTC date and time shall also be accurate, up to 10 days, when the NSC is powerless.
3. No batteries may be used to for the backup of the RTC.

R. Power Supply:

1. The 24 VDC power supply for the NSCs shall provide 30 watts of available power for the NSC and associated IO modules. The system shall support the use of more than one power supply if heavily power consuming modules are required.
2. The power supply, NSC, and I/O modules shall connect power wise and communication wise via the separate terminal base allowing for ease of replacement and no separate or loose wiring.

S. Automatic Restart After Power Failure:

1. Upon restoration of power after an outage, the NSC shall automatically and without human intervention update all monitored functions, resume operation based on current, synchronize time and status, and implement special start-up strategies as required.

T. Data Retention:

1. During a power failure, the NSC shall retain all programs, configuration data, historical data, and all other data that is configured to be retained.There shall be no time restriction for this retention and it must not use batteries to achieve it.

U. Software Specifications

1. The operating system of the controller, application programs, and all other portions of the configuration database such as graphics, trends, alarms, views, etc., shall be stored in non-volatile, FLASH memory. There will be no restrictions placed on the type of application programs in the system.Each NSC shall be capable of parallel processing, executing all control programs simultaneously.Any program may affect the operation of any other program.Each program shall have the full access of all I/O facilities of the processor.This execution of control function shall not be interrupted due to normal user communications including interrogation, program entry, printout of the program for storage, etc.
2. Each NSC shall have an available capacity of 4 GB of memory. This shall represent 2 GB for application and historical data and 2 GB dedicated for backup storage.

V. User Programming Language:

1. The application software shall be user programmable. This includes all strategies, sequences of operation, control algorithms, parameters, and setpoints. The source program shall be either a script-based structured text or graphical function block based and fully programmable by the user. The language shall be structured to allow for the configuration of control programs, schedules, alarms, reports, telecommunications, local displays, mathematical calculations, and histories.Users shall be able to place comments anywhere in the body of either script or function block programs.
2. Network Server Controllers that use a “canned” program method will not be accepted.

W. Control Software:

1. The NSC shall have the ability to perform the following pre-tested control algorithms:

    a. Proportional, Integral plus Derivative Control (PID)
    b. Two Position Control
    c. Digital Filter
    d. Ratio Calculator
    e. Equipment Cycling Protection

X. Mathematical Functions:

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

Y. NSCs shall have the ability to perform any or all of the following energy management routines:

1. Time of Day Scheduling
2. Calendar Based Scheduling
3. Holiday Scheduling
4. Temporary Schedule Overrides
5. Optimal Start
6. Optimal Stop
7. Night Setback Control
8. Enthalpy Switchover (Economizer)
9. Peak Demand Limiting
10. Temperature Compensated Duty Cycling
11. CFM Tracking
12. Heating/Cooling Interlock
13. Hot/Cold Deck Reset
14. Hot Water Reset
15. Chilled Water Reset
16. Condenser Water Reset
17. Chiller Sequencing

Z. History Logging:

1. Each NSC controller shall be capable of LOCALLY logging any input, output, calculated value or other system variable either over user defined time intervals ranging from 1 second to 1440 minutes or based upon a user configurable change of value.A minimum of 1000 logs, with a minimum of 100,000 records, shall be stored.Each log can record either the instantaneous, average, minimum or maximum value of the point.Logged data shall be downloadable to a higher level NSC long term archiving based upon user-defined time intervals, or manual command.
2. For extended trend logging a minimum of 1500 trends shall be capable, with a minimum number of 600,000 records within.
3. Management of a power meter replacement to ensure meter log data is accurate shall be possible in the NSC.
4. Every hardware input and output point, hosted within the NSC and attached I/O modules, shall be trended automatically without the requirement for manual creation, and each of these logs shall log values based upon a change of value and store at least 500 trend samples before replacing the oldest sample with new data.
5. The presentation of logged data shall be built into the server capabilities of the NSC. Presentation can be in time stamped list formats or in a chart format with fully configurable pen colors, weights, scales and time spans.
6. Tooltips shall be present, magnetic, and visible based on users preference.
7. Comments shall be visible whenever viewing the trend log list.

8. System shall give indication of memory usage and be able to alert the user if too many logs are allocated.
9. The BMS software and Network Servers shall support recording of all historical data, independent of any limitation in its local memory, which will be readily available for reporting and analysis without additional configurations or actions.
10. All historical data shall be available for use by the operator to access in BMS or a third-party reporting systems.

AA. Alarm Management:

1. For each system point, alarms can be created based on high/low limits or in comparison to other point values.All alarms will be tested each scan of the NSC and can result in the display of one or more alarm messages or reports.
2. There is no limit to the number of alarms that can be created for any point
3. Alarms can be configured to be generated based upon a single system condition or multiple system conditions.
4. Alarms will be generated based on an evaluation of the alarm conditions and can be presented to the user in a fully configurable order, by priority, by time, by category, etc. These configurable alarm views will be presented to a user upon logging into the system regardless of whether the log in takes place at a WorkStation or a Webstation.
5. The alarm management system shall support the ability to create and select cause and action notes to be selected and associated with an alarm event. Checklists shall also be possible in order to present to an operator a suggested mode of troubleshooting. When acknowledging an alarm, it shall be possible to assign it to a user of the system such that the user is notified of the assignment and is made responsible for the alarm resolution.
6. Alarms must be capable of being routed to any BACnet workstation that conforms to the B-OWS device profile and uses the BACnet/IP protocol.

BB. Embedded Web Server

1. Each NSC must have the ability to serve out web pages containing the same information that is available from the WorkStation.The development of the screens to accomplish shall not require any additional engineering labor over that required to show them at the WorkStation itself.
2. The NSC shall be configurable to logging all Embedded Web Server access attempts
3. The NSC shall have the option to redirect HTTP based Embedded Web Server connections to secure, HTTPS connections.
4. The NSC shall authenticate and authorize all users connecting to the Embedded Web Server
5. The NSC shall provide to ability to configure an automatic logoff for Embedded Web Server users that have not had any activity for an adjustable time period.

CC. The NSC controller shall comply with the following regulatory certifications

1. CE – EN 61000-6-3
2. CE – EN 61000-6-2
3. CE – EN 61010-1
4. CE – EN 61326-1
5. FCC CFR 47 Part 15 Class A
6. RCM
7. RoHS 2011/65/EU

8. China RoHS SJ/T 11364-2014
9. UL916 Energy Management equipment

DD. HMI

1. The NSC shall have an option for a tablet display
2. The tablet display shall be an industrial grade Human Machine Interface (HMI) that can be locked to the building management application to create a dedicated tool for local operation and maintenance.
3. The tablet display shall provide an easy-to-use interface through which users and engineers can locally access NSC's
4. The tablet display shall always start in a kiosk mode ensuring the end user can only use the device using the installed integration with the NSC.
5. The tablet display shall always require a password on start up
6. The tablet display shall require a password after a defined period of inactivity
7. The tablet display shall support being handheld or being installed on a control cabinet.
8. The tablet display user interface shall provide touchscreen navigation making it easy to operate and maintain the system.
9. The tablet display shall support robust physical panel mounting mechanisms provided with the product.
10. The tablet display shall have a screen size of 255mm or 10.1 inches
11. The tablet display shall support a screen resolution of 1280 by 800 pixels
12. The tablet display shall have a 16:10 aspect ratio
13. The tablet display shall be based on the Android platform
14. The tablet display shall have an IP54 rated frame that helps protect against dust and moisture.
15. The tablet display shall be powered by a 24 VDC power supply
16. The tablet display can be powered by a 24 VDC through the Y-shaped cable
17. The tablet display shall be able to communicate with the NSC over a wired (USB) connection running BACnet IP over USB.
18. The tablet display shall have an accessory Wi-Fi Module is an option instead of using USB for communication.

    a. Through the Wi-Fi module, you can establish wireless communication between the tablet display and the NCS connected to a wireless access point.
    b. The Wi-Fi module shall have an adhesive mount Wi-Fi antenna.
    c. The Wi-Fi module shall be compliant with IEEE 802.11 b/g/n
    d. The Wi-Fi module shall support enhanced wireless security using 64-bit and 128-bit WEP encryption

19. The tablet display shall connect to the NSC using only secure, HTTPS connections via the WebStation functionality of the NSC
20. The tablet display shall connect using a specific user and password combination defined as part of the NSC configuration

EE. Zoning (software defined zoning)

1. It shall be possible for BMS software and Network Servers (NSCs) to support synchronized control of lights, blinds and HVAC across multiple floorplan scenarios.
2. It shall be possible to create multiple synchronized control scenarios of lights/blinds/HVAC based to accommodate different floor plan scenarios.

3. It shall be possible to change synchronized control of lights/blinds/HVAC from one floorplan scenario to another manually or automatically.
4. It shall be possible to adapt synchronized controls of lights, blinds and HVAC to a different floorplan scenario using any device running a standard web browser.
5. It shall be possible for the administrator to manage user and group permissions to view / re-configure floor plan scenarios.

2.5 BACNET IP FIELDBUS CONTROLLERS

A. Controllers – BACnet/IP Protocol

1. All BACnet/IP Fieldbus controllers shall be BACnet Testing Laboratory listed (v12 or later) as specified BACnet Advanced Application Controller (B-AAC)
2. All BACnet/IP Fieldbus controllers shall use the following communication specifications and achieve performance as specified herein:

    a. All controllers shall be able to communicate peer-to-peer without the need for a NSC
    b. Any BACnet/IP Fieldbus controllers on the Ethernet Data Link/Physical layer shall be able to act as a Master to allow for the exchange and sharing of data variables and messages with any other controller connected on the same communication cabling. Slave controllers are not acceptable.

B. The BACnet/IP Fieldbus controllers shall be equipped with 2x 10/100bT Ethernet communication ports with active switch and will support BACnet/IP communication protocols with the following configurations:

1. Supporting IPv4 addressing
2. Supporting Static IP setting, DHCP client and Auto-IP address acquisition
3. It shall be possible to disable Ethernet port 2

C. Topologies

1. BACnet/IP Fieldbus controllers shall support daisy chain topology of up to 50 controllers.In case of any disruption to the communication, a system alarm shall notify the NSC/BMS of the point disruption has occurred.
2. BACnet/IP Fieldbus Controllers shall support RSTP loop whereby up to 39 controllers are supported.

    a. In case of any disruption there shall be no communication interruption
    b. In case of any disruption there shall be system alarms that will inform the operator of the disruption

D. Performance

1. Each BACnet/IP Fieldbus Controllers shall have a 32-bit microprocessor operating at 500 MHz and support a BACnet protocol stack in accordance with the ANSI/ASHRAE Standard 135-2008 and the BACnet Device Profile supported.
2. They shall be multi-tasking, real-time digital control processors consisting of communication controllers, controls processing, power supplies with built-in inputs and outputs.

E. Programmability

1. The BACnet/IP Fieldbus controllers shall support both script programming language and graphical that will be consistent with the NSC.
2. The control program will reside within the same enclosure as the input/output circuitry, that reads inputs and controls outputs
3. All control sequences programmed into the BACnet/IP Fieldbus Controllers shall be stored in non-volatile memory, which is not dependent upon the presence of a battery, to be retained.
4. BACnet/IP Fieldbus controllers shall communicate with the Network Server Controller (NSC) via a BACnet/IP connection at a baud rate of not less than 100 Mbps
5. BACnet/IP Fieldbus controllers shall support a dedicated communications port for connecting and supplying power to a matching room temperature and/or humidity sensor and/or CO2 and/or presence detector that does not utilize any of the I/O points of the controller.
6. BACnet/IP Fieldbus controllers (Excluding VAV) shall support an add-on display to supply and provide access in real-time for monitoring inputs and overriding of outputs
7. The override functionality must be supported by a dedicated processor to assure reliable operation (overriding of output)
8. Each BACnet/IP Fieldbus controller shall have sufficient memory, to support its own operating system and databases, including:

    a. Control processes
    b. Energy management applications
    c. Alarm management
    d. Historical/trend data
    e. Maintenance support applications
    f. Custom processes
    g. Manal override monitoring

9. Each BACnet/IP Fieldbus controller shall support local trend data up to 2x the built-in I/O and at a minimum be capable of holding 5 days @ 15 min intervals locally.
10. The BACnet/IP Fieldbus controller analog or universal input shall use a 16 bit A/D converter.
11. The BACnet/IP Fieldbus controller analog or universal output shall use a 10 bit D/A converter.
12. Built-in I/O: each BACnet/IP Fieldbus controllers shall support:

    a. At minimum 8 and up to 20 configurable IO channels to monitor and to control the following types of inputs and outputs without the addition of equipment inside or outside the DDC Controller cabinet.

        1) Universal Inputs – the following thermistors for use in the system without any external converters needed.

            a) 10 kohm Type I (Continuum)
            b) 10 kohm Type II (I/NET)
            c) 10 kohm Type III (Satchwell)
            d) 10 kohm Type IV (FD)
            e) Linearized 10 kohm Type V (FD w/11k shunt)
            f) Linearized 10 kohm (Satchwell)

g) 1.8 kohm (Xenta)
h) 1 kohm (Balco)
i) 20 kohm (Honeywell)
j) 2.2 kohm (Johnson)
k) PT100 (Siemens)
l) PT1000 (Sauter)
m) Ni1000 (Danfoss)

2) Analog inputs

a) Current Input - 0-20 mA
b) Voltage Input 0-10 Vdc

3) Digital inputs from dry contact closure, pulse accumulators, voltage sensing.
4) Digital outputs
5) Analog outputs of 4-20 mA and/or 0-10 Vdc

13. Real Time Clock (RTC):

a. Provide internal clocks for all BACnet Controllers (B-AAC) using BACnet time synchronization services.

1) Automatically synchronize system clocks daily from an operator-designated controller.
2) The system shall automatically adjust for daylight saving time.

b. Each BACnet/IP Fieldbus controller shall include a real time clock, accurate to +/- 1 minute per month.
c. The RTC shall provide the following: time of day, day, month, year, and day of week.
d. The RTC date and time shall also be accurate up to 7 days, from when the BACnet/IP Fieldbus controller has lost power with no reliance on.

14. The BACnet/IP Fieldbus controller for Variable Air Volume (VAV) applications

a. The BACnet/IP Fieldbus controller for VAV applications shall include a built-in ‘flow thru’ differential pressure transducer
b. The VAV differential pressure transducer shall have a measurement range of 0 to 1 in. W.C. and measurement accuracy of ±5% at 0.001 to 1 in. W.C. and a minimum resolution of 0.001 in. W.C., insuring primary air flow conditions shall be controlled and maintained to within ±5% of setpoint at the specified minimum and maximum air flow parameters
c. The BACnet/IP FieldBus controller for VAV applications shall support a dedicated commissioning tool for air flow balancing
d. The BACnet/IP Fieldbus controller for VAV applications shall require no programing for air balancing algorithm
e. All balancing parameters shall be synchronized in NSC

15. Each BACnet/IP Fieldbus controller shall have a minimum of 10% spare capacity for each point type represented on the controller for future point connection

16. Power Requirements. 24VDC (21 to 33 VDC) and 24 VAC +/-20% with local transformer power
17. Each BACnet/IP Fieldbus controller shall be accredited for smoke control and smoke management within a fully IP control solution
18. The BACnet/IP Fieldbus controller shall comply with the following regulatory certifications

    a. CE - EMCD 2014/30/EU
    b. CE LVD 2014/35/EU
    c. FCC CFR 47 Part 15 Class B
    d. RCM
    e. RoHS 2011/65/EU
    f. China RoHS SJ/T 11364-2014
    g. UL2043 (Plenum space mounting)
    h. UL916 Open-Energy Management equipment
    i. UL916 Energy Management equipment

19. Intelligent Space Sensor Interface –

    a. The BACnet/IP Fieldbus controllers shall support a dedicated RJ45 communication port to communicate and power up to 4 intelligent wall mount sensors without the use of on-board inputs or outputs
    b. It shall be possible to disable the RJ45 communication port.

20. The BACnet/IP Fieldbus controller for Connected Room solutions

    a. All BACnet/IP Fieldbus controllers shall be BACnet Testing Laboratory listed (v14 or later) as specified BACnet Advanced Application Controller (B-AAC)
    b. All BACnet/IP Fieldbus controllers shall use the following communication specifications and achieve performance as specified herein:

        1) All controllers shall be able to communicate peer-to-peer without the need for an NSC
        2) Any BACnet/IP Fieldbus controllers on the Ethernet Data Link/Physical layer shall be able to act as a Master to allow for the exchange and sharing of data variables and messages with any other controller connected on the same communication cabling. Slave controllers are not acceptable.

    c. The BACnet/IP Fieldbus controllers shall be equipped with 2x 10/100bT Ethernet communication ports with active switch and will support BACnet/IP communication protocols with the following configurations:

        1) Supporting IPv4 addressing
        2) Supporting Static IP setting, DHCP client and Auto-IP address acquisition
        3) It shall be possible to disable Ethernet port 2
        4) Each BACnet/IP controller shall be configurable to restrict communications to only whitelisted IP addresses.

d. Topologies

1) BACnet/IP Fieldbus controllers shall support daisy chain topology of up to 50 controllers. In case of any disruption to the communication, a system alarm shall notify the NSC/BMS of the point disruption has occurred.
2) BACnet/IP Fieldbus Controllers shall support RSTP loop whereby up to 39 controllers are supported.

    a) In case of any disruption there shall be no communication interruption
    b) In case of any disruption there shall be system alarms that will inform the operator of the disruption

e. Performance

1) Each BACnet/IP Fieldbus Controllers shall have a 32-bit microprocessor operating at 500 MHz and support a BACnet protocol stack in accordance with the ANSI/ASHRAE Standard 135-2012 and the BACnet Device Profile supported.
2) They shall be multi-tasking, real-time digital control processors consisting of communication controllers, controls processing, power supplies with built-in inputs and outputs.
3) Each BACnet/IP Fieldbus Controllers shall support upgrade of its firmware with no impact to its operation

f. Programmability

1) The BACnet/IP Fieldbus controllers shall support both script programming language and graphical that will be consistent with the NSC.
2) The control program will reside within the same enclosure as the input/output circuitry, that reads inputs and controls outputs
3) All control sequences programmed into the BACnet/IP Fieldbus Controllers shall be stored in non-volatile memory, which is not dependent upon the presence of a battery, to be retained.
4) The BACnet/IP Fieldbus controllers shall communicate with the Network Server Controller (NSC) via a BACnet/IP connection at a baud rate of not less than 100 Mbps
5) The BACnet/IP Fieldbus controllers shall support two RS485 communication ports for connecting and supplying power to a range of protocol types

    a) BACnet/IP Fieldbus controllers shall support configurable selection of the supported protocol on the RS485 communications ports,
    b) BACnet/IP Fieldbus controllers shall support a communications capability for connecting and supplying power to a matching room temperature and/or humidity sensor and/or CO2 and/or presence detector that does not utilize any of the I/O points of the controller.
    c) BACnet/IP Fieldbus controllers shall support a communications capability for connecting and supplying power to a matching connected module for the purpose of control of lights and blinds that do not utilize any of the I/O points of the controller

d) BACnet/IP Fieldbus controllers shall support a communications capability for connecting to open market Modbus devices

g. BACnet/IP Fieldbus controllers shall support on-board Bluetooth Low Energy radio to support:

1) Mobile application shall be available for controller commissioning
2) Mobile applications shall be available for building occupants
3) It shall be possible to disable the Bluetooth Low Energy Radio
4) The BACnet/IP Fieldbus controller shall support a connection for an external antenna.

h. BACnet/IP Fieldbus controllers shall support an optional plug-in Zigbee 3.0 radio for the purpose of connecting to wireless Zigbee sensors and devices.

1) It shall be possible to connect to up to 16 Zigbee sensors or devices
2) The controller shall support a range of different sensors and devices for easy commissioning
3) The controller shall be able to connect to a Green Power Zigbee temperature and humidity sensor with 10 years of battery life
4) The controller shall be able to connect to a Zigbee temperature, humidity and CO2 sensor with 10 years of battery life

i. Controllers that only support older versions of the Zigbee 3.0 are not approved due to the lack of security layer
j. It shall be possible to connect the Zigbee radio directly to the BACnet/IP RP Fieldbus controller.
k. It shall be possible to install the Zigbee radio in the ceiling using a purpose designed extension cable and ceiling housing when radio reception at the controller may be compromised.
l. Each BACnet/IP Fieldbus controller shall have sufficient memory, to support its own operating system and databases, including:

1) Control processes
2) Energy management applications
3) Alarm management
4) Historical/trend data
5) Maintenance support applications
6) Custom processes

m. In the case of communication disruption between the BACnet/IP Fieldbus controller and NSC/BMS, each BACnet/IP Fieldbus controller shall support storage of local trend data up to 2x the number of its built-in I/O at the collection rate of 5 min for 5 days.
n. The BACnet/IP Fieldbus controller analog or universal input shall use a 16-bit A/D converter.
o. The BACnet/IP Fieldbus controller analog or universal output shall use a 10-bit D/A converter.

p. Built-in I/O: each BACnet/IP Fieldbus controllers shall support:

1) Up to 8 configurable IO channels to monitor and to control the following types of inputs and outputs without the addition of equipment inside or outside the DDC Controller cabinet.

a) Universal Inputs – the following thermistors for use in the system without any external converters needed.
b) 10K Ohm Type I (Continuum)
c) 10K Ohm Type II (I/NET)
d) 10K Ohm Type III (Satchwell)
e) 10K Ohm Type IV (FD)
f) Linearized 10K Ohm Type V (FD w/11k shunt)
g) Linearized 10K Ohm (Satchwell)
h) 1.8K Ohm (Xenta)
i) 1K Ohm (Balco)
j) 20K Ohm (Honeywell)
k) 2.2K Ohm (Johnson)
l) PT100 (Siemens)
m) PT1000 (Sauter)
n) Ni1000 (Danfoss)
o) Voltage Input - 0-10 Vdc
p) Digital inputs from dry contact closure, pulse accumulators, voltage sensing.
q) Digital outputs
r) Analog outputs 0-10 Vdc

q. Internal Clock

1) Provide internal clocks for all BACnet Controllers (B-AAC) using BACnet time synchronization services.

a) Automatically synchronize system clocks daily from an operator-designated controller.
b) The system shall automatically adjust for daylight saving time.

2) Each BACnet/IP Fieldbus controller shall include a real time clock, accurate to +/-1 minute per month.
3) The RTC shall provide the following: time of day, day, month, year, and day of week.
4) The RTC date and time shall also be accurate up to 7 days, from when the BACnet/IP Fieldbus controller has lost power with no reliance on batteries

r. Each BACnet/IP Fieldbus controller shall have a minimum of 10% spare capacity for each point type represented on the controller for future point connection
s. Power Requirements. 24VDC (21 to 33 VDC) and 24 VAC +/-20% with local transformer power
t. Power Requirements. A line voltage version shall be available 230 VAC
u. In the case of power disruption, each BACnet/IP Fieldbus controller shall support power failure recovery within 10 seconds and resume operation from where the disruption had occurred

v. The BACnet/IP Fieldbus controller shall be able to be plenum mounted (UL2043 compliant)
w. The BACnet/IP Fieldbus controller shall meet the open class standard of UL916 permitting its installation without secondary enclosure where appropriate
x. The BACnet/IP Fieldbus controller shall comply with the following regulatory certifications

1) CE - EMCD 2014/30/EU
2) CE LVD 2014/35/EU
3) FCC CFR 47 Part 15 Class B
4) RCM
5) RoHS 2011/65/EU
6) China RoHS SJ/T 11364-2014
7) UL2043 (Plenum space mounting)
8) UL916 Open-Energy Management equipment
9) UL916 Energy Management equipment

y. Intelligent Space Sensor Interface - The BACnet/IP Fieldbus controllers shall support an RJ45 communication port to communicate and power up to 4 intelligent wall mount sensors without the use of on-board inputs or outputs

1) It shall be possible to disable the RJ45 communication port

z. Integrations - Connected Room

1) The controller shall be capable of controlling lighting fixtures thru various open protocols listed below. this shall be achieved thru on-board I/O on the controller or via expansion modules (of the BACnet/IP controller) and will be capable of supporting the following:

a) The DALI expansion module shall be certified and capable of full DALI2 control for individual and groups of lights (up to 32 ballasts or LED drivers and a maximum of 16 groups).
b) During zero light output it shall be possible to fully shut down the ballasts thereby minimizing any leakage current.
c) The controller / expansion module shall be certified for multi-master functionality thereby allowing DALI pushbuttons sensors and dimmers to be mounted on the DALI communication bus.
d) The DALI expansion module shall be rated to 10A in total (Max 5A per channel)
e) The DALI expansion module shall support DALI version-1 control gear
f) The DALI expansion module shall support DALI-1 version control gear.
g) The DALI expansion module shall support Discharge lamps
h) The DALI expansion module shall support LED
i) The DALI expansion module shall support color control (Device type 8)
j) The DALI expansion module shall support feedback from control gear (including lamp failure feedback)

k) The DALI expansion module shall support addressing and grouping of control gear.
l) The 0-10V expansion modules shall be capable of on/off/dim of light using 0-10V dimming signal.
m) During zero light output it shall be possible to fully shut down the ballasts thereby minimizing any leakage current.
n) It shall be possible to interface and control lighting that are dimmed using Phase cut dimming the controller/interface shall be capable of automatically detecting the appropriate leading or trailing edge control mechanism that may be needed depending on the type of load.

2) The controller shall be capable of controlling blinds and shades thru various open protocols listed below. this shall be achieved thru on-board I/O on the controller or via expansion modules (of the BACnet/IP controller) and will be capable of supporting the following:

a) The controller/ expansion modules shall be capable of interfacing with and controlling blind motors that uses low voltage Standard Motor Interface (SMI) communication.
b) The controller/ expansion modules shall be capable of interfacing with and controlling blind motors that use high voltage SMI communication.
c) The controller/ expansion modules shall be capable of interfacing with and controlling blind motors using low voltage (24V) relays.
d) The controller/ expansion modules shall be capable of interfacing with and controlling blind motors using line voltage relays.

3) It shall be possible for the controller to interface with third party Modbus devices sensors, pushbuttons and glass touch panels
4) It shall be possible for the controller to interface with KNX sensors and push button devices
5) It shall be possible for the controller to communicate to wireless devices such as sensors, power meters, and wireless lighting control gateways via Zigbee 3.0.

a) Controllers using earlier Zigbee standards shall not be acceptable.

6) It shall be possible to rezone and partition spaces using a graphical software, that works using floor plan maps and allows the user to create zones by positioning HVAC equipment, lights, blinds and sensors directly on the map. It shall then be possible to assign them to zones
7) It shall be possible to connect to four advanced sensors with capability for sensing occupancy and light levels. The sensor shall be powered by the controller and will not require batteries for operation.
8) it shall be possible to control lights/ blinds and HVAC functions such as fan speed and temperature via an optional remote control that can be located anywhere conveniently within the room or mounted on the wall and communicates to the controller securely via blue-tooth
9) It shall be possible for the controller to measure the power consumed by the different devices connected to the controller such as lighting HVAC and blinds

10) Lighting Control Interfaces

a) Mobile Based Personal Control Interface - an integrated mobile application shall provide current status of the light and blind in the room and enable each room occupant with the ability to:
b) Dim, brighten lights and turn them on and off
c) And for blinds: tilt, vertical up or down
d) Ability to select scenes
e) Control HVAC

11) The Connected Room Solution will be fully programmable capable of supporting different control strategies locally.
12) Standard applications shall be available for download from a central repository, which will allow common configurations such as those listed below to be easily configured.

a) Occupied state
b) Unoccupied state
c) Load Shed Mode
d) Daylight Harvesting
e) Time Clock Scheduling

13) The integration modules shall comply with the following regulatory certifications

a) CE - EMCD 2014/30/EU
b) CE LVD 2014/35/EU
c) FCC CFR 47 Part 15 Class B
d) RCM
e) RoHS 2011/65/EU
f) China RoHS SJ/T 11364-2014
g) UL2043 (Plenum space mounting)
h) UL916 Energy Management

21. The BACnet/IP Fieldbus controller for remote IO

a. It shall be possible to extend Inputs / Outputs required in NSC or BACnet/IP Fieldbus Controllers over the IP network
b. The BACnet/IP IO expansion device shall be equipped with 2x 10/100bT Ethernet communication ports with active switch supporting the following configurations:

1) Supporting IPv4 addressing
2) Supporting Static IP setting, DHCP client and Auto-IP address acquisition
3) It shall be possible to disable Ethernet port 2

c. The BACnet/IP IO expansion device shall support daisy and RSTP topologies
d. The BACnet/IP I/O expansion device shall be capable of sharing its local I/O resources with one or multiple applications distributed across one or multiple NSCs or BACnet/IP Fieldbus Controllers.
e. The BACnet/IP I/O expansion device shall support BACnet Alarm and Trend locally

f. Outputs of the BACnet/IP I/O expansion device shall support user configurable fallback value that is triggered in case of communication disruption.

F. Commissioning Tool - The BACnet/IP Fieldbus controllers shall be supported via a dedicate mobile based commissioning tool for configuration, programming, air balancing and I/O checkout:

1. The Commissioning Tool shall be supported across: iOS, Android and Windows 10 platforms
2. The Commissioning Tool shall be available for download on App Store, Google Store and Windows Store
3. Commissioning Tool Interface to BACnet/IP Fieldbus controllers shall be via Bluetooth or via a Wi-Fi access point on the LAN
4. Functionality

    a. Device Configuration – the Commissioning Tool shall be able to set or edit all Network configurations associated with the BACnet/IP Fieldbus controller
    b. Programming – The Commissioning Tool shall be able to load offline engineered applications directly in to the controller directly
    c. Air Balancing

        1) The Commissioning Tool shall allow the air balancer to manually control the action of the actuator including the following function: open VAV damper, close VAV damper, open all VAV dampers, and close all VAV dampers.
        2) The Commissioning Tool shall be able to generate Air Balancing report

    d. DALI lighting commissioning

        1) The Commissioning tool shall allow the engineer to test the operation of DALI control gear.
        2) The commissioning tool shall allow the engineer to wink the DALI control gear.
        3) The commissioning tool shall indicate the status of the DALI control gear.

    e. 0-10V lighting commissioning

        1) The Commissioning tool shall allow the engineer to test the operation of 0-10V lights.
        2) The commissioning tool shall allow the engineer to wink the 0-10V lights.

    f. Blind and shade commissioning

        1) The Commissioning tool shall allow the engineer to test the operation of blinds and shades.

5. IO Checkout

    a. The Commissioning Tool shall be able to support overriding of the outputs and reading value of inputs live that includes light and blind points and their configuration

b. The Commissioning Tool shall be able to support generation of I/O checkout report

6. There shall be no limit to the number of Commissioning Tools that can be used on a network segment.

G. Intelligent Space Sensors - The BACnet/IP Fieldbus controller shall support a dedicated RJ45 communication port to communicate and power up to 4 intelligent wall mount sensors without the use of on board inputs or outputs

1. The Intelligent Space Sensor shall communicate with the BACnet/IP Fieldbus controller through the sensor port and via category 5 or category 6 cable
2. The Intelligent Space Sensor shall provide 2 RJ45 communication ports that will allow communication with parent BACnet/IP Field controller upstream and additional Intelligent Space Sensors downstream
3. The Intelligent Space Sensor shall provide ambient space condition sensing without the use of hardware I/O

H. Each Intelligent Space Sensor shall provide a color touch display with:

1. Minimum 2.4” by 2.4” display
2. Backlit

I. The Intelligent Space Sensor shall be capable of displaying measured space temperature from 32 to 122 °F with accuracy of ±0.4 °F selectable for 0.1 or 1 degree display resolution of °F.

1. Sensing Element: 10k Type 3 Thermistor
2. Accuracy of ±0.4 °F
3. Resolution: 0.1 or 1 degree display resolution
4. Range: 32 to 122 °F

J. The Intelligent Space Sensor shall have the option for humidity sensor support sensing humidity from 0 % RH to 100 % RH Digital humidity indication (selectable for 0.1 or 1% RH with selectable display resolution of 0.1 or 1 % RH

1. Accuracy: ±2 % RH
2. Resolution: 0.1 or 1 % RH
3. Range: 0 % RH to 100 % RH

K. The Intelligent Space Sensor shall have the option for support of CO2 sensor with display resolution with 0 to 2000 ppm resolution

1. Accuracy: ±30 ppm ±2% of measured value
2. Range: 0 to 2,000 ppm
3. Operating elevation: 0 to 16,000 ft.
4. Temperature dependence: 0.11% FS per ˚F
5. Stability: <2% of FS over life of sensor (15 years)
6. Sensing method: Non-dispersive infrared (NDIR), diffusion sampling

L. The Intelligent Space Sensor shall have the option for motion sensor

M. Display options:The Intelligent Space Sensor shall be capable of displaying the following elements:

1. Space temperature
2. Cooling space temperature set point
3. Heating space temperature set point
4. Current heating or cooling mode
5. Current occupancy mode
6. Fan speed
7. Current time
8. Light control
9. Blind adjustment
10. Scene selection

2.6 DDC SENSORS AND POINT HARDWARE

A. Temperature Sensors

1. Acceptable Manufacturers: Veris Industries
2. All temperature devices shall use precision thermistors accurate to +/- 1 degree F over a range of –30 to 230 degrees F.Space temperature sensors shall be accurate to +/- .5 degrees F over a range of 40 to 100 degrees F.
3. Room Sensor: Standard space sensors shall be available in an off white enclosure made of high impact ABS plastic for mounting on a standard electrical box. Basis of Design: Veris TW Series

    a. Where manual overrides are required, the sensor housing shall feature both an optional sliding mechanism for adjusting the space temperature setpoint, as well as a push button for selecting after hours operation.
    b. Where a local display is specified, the sensor shall incorporate an LCD display for viewing the space temperature, setpoint and other operator selectable parameters.Using built in buttons, operators shall be able to adjust setpoints directly from the sensor.

4. Duct Probe Sensor: Sensing element shall be fully encapsulated in potting material within a stainless steel probe. Useable in air handling applications where the coil or duct area is less than 14 square feet. Basis of Design: Veris TD Series
5. Duct Averaging Sensor: Averaging sensors shall be employed in ducts which are larger than 14 square feet.The averaging sensor tube shall contain at least one thermistor for every 3 feet, with a minimum tube length of 6 feet. The averaging sensor shall be constructed of rigid or flexible copper tubing. Basis of Design: Veris TA Series
6. Pipe Immersion Sensor: Immersion sensors shall be employed for measurement of temperature in all chilled and hot water applications as well as refrigerant applications. Provide sensor probe length suitable for application. Provide each sensor with a corresponding pipe-mounted sensor well, unless indicated otherwise. Sensor wells shall be stainless steel for non-corrosive fluids below 250 degrees F and 300 series stainless steel for all other applications. Basis of Design: Veris TI Series
7. Outside Air Sensor:Provide the sensing element on the building's north side. Sensing element shall be fully encapsulated in potting material within a stainless steel probe. Probe shall be encased in PVC solar radiation shield and mounted in a weatherproof enclosure. Operating range -40 to 122 F, Basis of Design: Veris TO Series

8. A pneumatic signal shall not be allowed for sensing temperature.

B. Humidity Wall Transmitter

1. Acceptable Manufacturer: Veris Industries
2. Transmitters shall be accurate to +/- 2 % at full scale.
3. Transmitter shall have replaceable sensing element.
4. Sensor type shall be thin-film capacitive.
5. Sensor element shall contain multipoint calibration on-board in nonvolatile memory
6. Operating range shall be 0 - 100% RH noncondensing, 50 to 95 F
7. Output shall be field selectable 4-20 mA or 0-5/0-10 VDC.
8. Transmitter shall accept 12-30 VDC or 24 VAC supply power.
9. Transmitter shall be available in an off white enclosure made of high impact ABS plastic for mounting on a standard electrical box.
10. Transmitter shall have option of having an LCD display
11. Transmitter shall have option of being NIST certified
12. Transmitter shall have option of an integrated temperature sensor
13. Basis of Design: Veris HWL Series

C. Humidity Duct Transmitter

1. Acceptable Manufacturer: Veris Industries
2. Transmitters shall be accurate to +/- 2 % at full scale.
3. Transmitter shall be fully encapsulated in potting material within a stainless steel probe.
4. Transmitter shall have replaceable sensing element.
5. Sensor type shall be thin-film capacitive.
6. Sensor element shall contain multipoint calibration on-board in nonvolatile memory
7. Operating range shall be 0 - 100% RH noncondensing, -40 to 122 F
8. Output shall be 4-20 mA or 0-5/0-10 VDC.
9. Transmitter shall accept 12-30 VDC or 24 VAC supply power.
10. Transmitter shall have option of being NIST certified
11. Transmitter shall have option of an integrated temperature sensor
12. Basis of Design: Veris HD Series

D. Humidity Outdoor Transmitter

1. Acceptable Manufacturer: Veris Industries
2. Transmitters shall be accurate to +/- 2% at full scale.
3. Transmitter shall be fully encapsulated in potting material within a stainless steel probe. Probe shall be encased in PVC solar radiation shield and mounted in a weatherproof enclosure.
4. Transmitter shall have replaceable sensing element.
5. Sensor type shall be thin-film capacitive.
6. Sensor element shall contain multipoint calibration on-board in nonvolatile memory
7. Operating range shall be 0 - 100% RH noncondensing, -40 to 122 F
8. Output shall be 4-20 mA or 0-5/0-10 VDC.
9. Transmitter shall accept 12-30 VDC or 24 VAC supply power.
10. Transmitter shall have option of being NIST certified
11. Transmitter shall have option of an integrated temperature sensor
12. Basis of Design: Veris HO Series

E. Carbon Dioxide Wall Transmitter:

1. Acceptable Manufacturer: Veris Industries
2. Sensor type shall be Non-dispersive infrared (NDIR).
3. Accuracy shall be ±30 ppm ±2% of measured value with annual drift of ±10 ppm.Minimum five year recommended calibration interval.
4. Repeatability shall be ±20 ppm ±1% of measured value
5. Response Time shall be <60 seconds for 90% step change
6. Outputs shall be field selectable Analog: 4-20mA or 0-5/0-10VDCProtocol: BACnet with [SPDT Relay 1A@30VDC][temperature setpoint slider]
7. Transmitter shall accept 12-30 VDC or 24 VAC supply power.
8. Temperature Range: [32° to 122°F (CO2 only)][50° to 95°F (with humidity option)]
9. Output range shall be programmable 0-2000 or 0-5000 ppm
10. Transmitter shall be available in an off white enclosure for mounting on a standard electrical box.
11. Transmitter shall have an option of an LCD display for commissioning and provide additional faceplate to conceal LCD display where occupants may misinterpret CO2 readings.
12. Transmitter shall have option of an integrated temperature sensor and/or humidity sensor
13. Basis of Design: Veris CWL

F. Carbon Dioxide Duct Transmitter:

1. Acceptable Manufacturer: Veris Industries
2. Sensor type shall be Non-dispersive infrared (NDIR).
3. Accuracy shall be ±30 ppm ±2% of measured value with annual drift of ±10 ppm.Minimum five year recommended calibration interval.
4. Repeatability shall be ±20 ppm ±1% of measured value
5. Response Time shall be <60 seconds for 90% step change
6. Outputs shall be field selectable Analog: 4-20mA or 0-5/0-10VDC with SPDT Relay 1A@30VDC
7. Transmitter shall accept 12-30 VDC or 24 VAC supply power.
8. Temperature Range: 32° to 122°F
9. Output range shall be programmable 0-2000 or 0-5000 ppm
10. Enclosure shall not require remote pickup tubes and make use of integrated H-beam probe to channel air flow to sensor.
11. Enclosure lid shall require no screws and make use of snap on features for attachment
12. Enclosure shall be made of high impact ABS plastic
13. Transmitter shall have option of an LCD display
14. Transmitter shall have option of an integrated temperature sensor and/or humidity sensor
15. Basis of Design: Veris CDL

G. Air Pressure Transmitters.

1. Acceptable Manufacturers: Veris Industries
2. Sensor shall be microprocessor profiled ceramic capacitive sensing element
3. Transmitter shall have 14 selectable ranges from 0.1 – 10” WC
4. Transmitter shall be +/- 1% accurate in each selected range including linearity, repeatability, hysteresis, stability, and temperature compensation.
5. Transmitter shall be field configurable to mount on wall or duct with static probe
6. Transmitter shall be field selectable for Unidirectional or Bidirectional

7. Maximum operating pressure shall be 200% of design pressure.
8. Output shall be field selectable 4-20 mA or 0-5/0-10 VDC linear.
9. Transmitter shall accept 12-30 VDC or 24 VAC supply power
10. Response time shall be field selectable T95 in 20 sec or T95 in 2 sec
11. Transmitter shall have an LCD display
12. Units shall be field selectable for WC or PA
13. Transmitter shall have provision for zeroing by pushbutton or digital input.
14. Transmitter shall be available with a certification of NIST calibration
15. Basis of Design: Veris model PXU.

H. Liquid Differential Pressure Transmitters:

1. Acceptable Manufacturer: Veris Industries
2. Transmitter shall be microprocessor based
3. Transmitter shall use two independent gauge pressure sensors to measure and calculate differential pressure
4. Transmitter shall have 4 switch selectable ranges
5. Transmitter shall have test mode to produce full-scale output automatically.
6. Transmitter shall have provision for zeroing by pushbutton or digital input.
7. Transmitter shall have field selectable outputs of 0-5V, 0-10V, and 4-20mA.
8. Transmitter shall have field selectable electronic surge damping
9. Transmitter shall have an electronic port swap feature
10. Transmitter shall accept 12-30 VDC or 24 VAC supply power
11. Sensor shall be 17-4 PH stainless steel where it contacts the working fluid.
12. Performance:

    a. Accuracy shall be ±1% F.S. and ±2% F.S. for lowest selectable range
    b. Long term stability shall be ±0.25%
    c. Sensor temperature operating range shall be -4° to 185°F
    d. Operating environment shall be 14° to 131°F; 10-90% RH noncondensing
    e. Proof pressure shall be 2x max. F.S. range
    f. Burst pressure shall be 5x max. F.S. range

13. Transmitter shall be encased in a NEMA 4 enclosure
14. Enclosure shall be white powder-coated aluminum
15. Transmitter shall be available with a certification of NIST calibration
16. Transmitter shall be preinstalled on a bypass valve manifold
17. Basis of Design: Veris PW

I. Current Sensors

1. Current status switches shall be used to monitor fans, pumps, motors and electrical loads.Current switches shall be available in split core models, and offer either a digital or an analog signal to the automation system. Acceptable manufacturer is Veris Industries

J. Current Status Switches for Constant Load Devices

1. Acceptable Manufacturer: Veris Industries
2. General: Factory programmed current sensor to detect motor undercurrent situations such as belt or coupling loss on constant loads.Sensor shall store motor current as operating parameter in non-volatile memory.Push-button to clear memory.

3. Visual LED indicator for status.
4. Split core sensor, induced powered from monitored load and isolated to 600 VAC rms.Sensor shall indicate status from 0.5 A to 175 A.
5. Normally open current sensor output.0.1A at 30 VAC/DC.
6. Basis of Design: Veris Model H608.

K. Current Status Switches for Constant Load Devices (Auto Calibration)

1. Acceptable Manufacturer: Veris Industries.
2. General: Microprocessor based, self-learning, self-calibrating current switch. Calibration-free status for both under and overcurrent, LCD display, and slide-switch selectable trip point limits. At initial power-up automatically learns average current on the line with no action required by the installer
3. Split core sensor, induced powered from monitored load and isolated to 600 VAC rms.Sensor shall indicate status from 2.5 A to 200 A.
4. Display: Backlit LCD; illuminates when monitored current exceeds 4.5A
5. Nominal Trip Point: ±40%, ±60%, or on/off (user selectable)
6. Normally open current sensor output.0.1A at 30 VAC/DC.
7. Basis of Design: Veris Model H11D.

L. Current Status Switches for Variable Frequency Drive Application

1. Acceptable Manufacturer: Veris Industries.
2. General: Microprocessor controlled, self-learning, self-calibrating current sensor to detect motor undercurrent and overcurrent situations such as belt loss, coupling shear, and mechanical failure on variable loads.Sensor shall store motor current as operating parameter in non-volatile memory.Push-button to clear memory and relearn.
3. Visual LED indicator for status.
4. Alarm Limits: ±20% of learned current in every 5 Hz freq. band
5. Split core sensor, induced powered from monitored load and isolated to 600 VAC rms.Sensor shall indicate status from 1.5 A to 150 A and from 12 to 115 Hz.
6. Normally open current sensor output.0.1A at 30 VAC/DC.
7. Basis of Design: Veris Model H614.

M. Liquid Flow, Insertion Type Turbine Flowmeter:

1. Acceptable Manufacturer: Veris Industries
2. General: Turbine-type insertion flow meter designed for use in pipe sizes 1 1/2” and greater. Available in hot tap configuration with isolation valves and mounting hardware to install or remove the sensor from pipeline that is difficult to shut down or drain
3. Performance:

    a. Accuracy ±1% of rate over optimum flow range; ≥10 upstream and ≥5 downstream straight pipe diameters, uninterrupted flow
    b. Repeatability ±0.5%
    c. Velocity Range: 0.3 to 20 FPS
    d. Pressure Drop 0.5 psi or less @ 10 ft/sec for all pipe sizes 1.5” dia and up
    e. Pressure Rating: 1000 psi @ 70°F

4. Maximum Temperature Rating: 300°F
5. Materials: Stainless Steel or Brass body; Stainless steel impeller

6. Transmitter:

    a. Power Supply: 12 - 30VAC or 8 - 35VDC.
        1) Output: [Frequency][4-20 mA][Scaled Pulse]
    b. Temperature Range: 14° to 150°F
    c. Display: 8 character 3/8" LCD (Optional)
    d. Enclosure: NEMA 4, Polypropylene with Viton® sealed acrylic cover

7. Basis of Design: Veris SDI series

N. Liquid Flow/Energy Transmitter, Non-invasive Ultrasonic (Clamp-on):

1. Acceptable Manufacturer: Veris Industries
2. General: Clamp-on digital correlation transit-time ultrasonic flow meter designed for clean liquids or liquids containing small amounts of suspended solids or aeration. Optional temperature sensors for BTU calculations.
3. Liquid: water, brine, raw sewage, ethylene, glycol, glycerin, others. Contact manufacturer for other fluid compatibility
4. Pipe Surface Temperature: Pipe dia 1/2” to 2”:-40-185°F; Pipe dia> 2”: -40-250°F
5. Performance:

    a. Flow Accuracy:

        1) Pipe dia 1/2” to 3/4” 1% of full scale
        2) Pipe dia 1” to 2” 1% of reading from 4-40 FPS
        3) Pipe dia 2” to 100” 1% of reading from 1-40 FPS

    b. Flow Repeatability ±0.01% of reading
    c. Velocity Range: (Bidirectional flow)

        1) Pipe dia 1/2” to 2” 2 to 40 FPS
        2) Pipe dia 2” to 100” 1 to 40 FPS

    d. Flow Sensitivity 0.001 FPS
    e. Temperature Accuracy (energy): 32-212°F; Absolute 0.45°F; Difference 0.18°F
    f. Temperature Sensitivity: 0.05°F
    g. Temperature Repeatability: ±0.05% of reading

6. Transmitter:

    a. Power Supply: 95 to 264 VAC, 47 to 63 Hz or 10 to 28 VDC.
    b. Output: [RJ45][Modbus TCP/IP][Ethernet/IP][BACnet/IP][Pulse][4-20 mA][RS-485 Modbus RTU}
    c. Temperature Range: -40 to +185°F
    d. Display: 2 line backlit LCD with keypad
    e. Enclosure: NEMA 4, (IP65), Powder-coated aluminum, polycarbonate

7. Agency Rating: UL 1604, EN 60079-0/15, CSA C22.2, CSA Class 1 (Pipe > 2”)
8. Basis of Design: Veris FST & FSR series

O. Analog Electric/Pneumatic Transducer:

1. Acceptable Manufacturer: Veris Industries
2. General: Micro-controlled poppet valve for high accuracy and with no air loss in the system. Field configurable for pressure sensing in multiple applications.
3. Power Supply: 22-30VDC, 20-30VAC
4. Control Input: 4-20mA, 0-10V, 0-5V; jumper selectable
5. Performance:

    a. Accuracy: 1% full scale; combined linearity, hysteresis, repeatability
    b. Compensated Temperature Range: 25° to 140°F
    c. Temp Coefficient: ±0.05%°C
    d. Operating Environment: 10-90% RH, non-condensing; 25° to 140°F

6. Supply Pressure: 45 psig max.
7. Manual Override: Jumper selectable mode, digital pushbutton adjust
8. Alarm Contact: 100mA@30VAC/DC (Optional)
9. Control Range 0-20 psig or 3-15 psig; jumper selectable
10. Pressure Differential 0.1 psig (supply to branch)
11. Pressure Indication Electronic, 3-1/2 digit LCD
12. Housing: Mounted on standard SnapTrack; Optional clear dust cover
13. Basis of Design: Veris EP Series

P. Water Control Valves

1. Ball Valves

    a. ½" to ¾" Ball Valve

        1) Forged brass body rated at no less than 600 psi, chrome plated brass ball with blowout proof stem or optional stainless steel ball with blowout proof stem,
        2) Valves are to be in two-way and three-way configurations.
        3) Connection: Female NPT end fittings, Teflon® PTFE seat, characterizing disc glass filled PEEK providing equal percentage flow curve on two-way valve.
        4) Operating Temperature 20…250°F chilled or hot water with up to 60% glycol solution.
        5) Two-way and Bypass port should be ANSI Class IV (0.01% of Cv) seat leakage.
        6) Rangeability must be at least 300:1.
        7) Tool-less actuator connection.
        8) System Static Pressure Limit should be 600 psig (4137 Pa)
        9) Basis of Design:Schneider Electric VBB/VBS Ball Valves, or BELIMO.

    b. ½" to 3" 2-way and ½" to 2" 3-way Ball Valves

        1) Valves must be for control of hot or chilled water, or solutions of up to 50% glycol.
        2) Ball valves must have close-offs of 40…130 psi depending on size.
        3) Valves will provide CVs from 0.33…266 depending on size.

4) Valve characterizing insert, is to be made of glass-filledNoryl™ and provide equal percentage flow.
5) Valve body is to be made of forged brass ASTM B283-06 and rated for static pressure of 360 psi at fluid temperatures of 20…250°F.
6) All valves are to have balls made of nickel/chromium plated brass with two-way valves having stainless steel balls as an option. All valve stems are to be stainless steel with reinforce Teflon® EPDM O-ring seals.
7) 2-way valves are to be ANSI Class IV (0.01% of Cv) shutoff. 3-way valves are to be ANSI Class IV (0.01% of Cv piped coil-side outlet to the port A only.
8) Fluid (water) temperature are a minimum 20°F and a maximum of 250°F (121°C).
9) Basis of Design: Schneider Electric VB-2000, orBELIMO.

2. Globe Valves (Bronze ½" to 2")

a. Control Valves: Factory fabricated, with body material, and pressure class based on maximum pressure and temperature rating of piping system with a body rating of not less than 400 psig at 150°F, 321 psig at 281°F per ANSI B16.15.
b. Valves two way NPS 2" and Smaller: Operator, stem and plug assembly, and spring-loaded PTFE/EPDM valve stem packing cartridge must be removable for future replacement to restore the valves back to their original condition. Material grade properties must meet the fluid temperature and pressure requirements:

1) Standard duty bronze body, 316 stainless steel vertical stem, brass plug, soft seal, and bronze seat, renewable packing cartridge, and screwed/sweat/flared ends. Valves shall have allowable media temperature of 20°F …281°F to assure reliability with dual temperature applications.
2) Heavy duty bronze body, 316 stainless steel vertical stem, 316 stainless steel plug, soft seal, and 316 stainless steel seat, renewable packing cartridge, and screwed ends. Valves shall have allowable media temperature of 20°F …340°F to assure to assure reliability with dual temperature applications.
3) High temperature bronze body, 316 stainless steel vertical stem, 316 stainless steel plug, and 316 stainless steel seat, renewable packing cartridge, and screwed ends. Valves shall have allowable media temperature of 20°F …400°F.

c. Two-way fluid system globe valves shall have the following characteristics:

1) Rangeability: Greater than 100:1 for all valves with flow coefficients of 0.4 and higher to provide stable control under light load conditions.
2) Maximum Allowable Seat Leakage: Standard and heavy duty valves must be designed to meet ANSI Class V (0.0005 ml per minute per "of orifice diameter per psi differential) up to 35 psi close off differential pressure and ANSI Class IV seat leakage (maximum 0.01% of full open valve capacity) above 35 psi with appropriate actuator. High temperature valves must meet ANSI Class III seat leakage (maximum 0.1% of full open valve capacity).
3) The valve must be able to operate with a full-open operating differential of no less than 87 psi.

4) Flow Characteristics: Modified equal percentage characteristics for standard duty water applications and modified linear for heavy duty and high temperature steam applications with gradual opening for light loads.
5) Sizing:

a) Two Position Water: Water: Line size or size using a differential pressure of 1 psi.
b) Modulating Water: 5 PSI or twice the load pressure drop.
c) Pressure drop across steam valve at a maximum flow of 80 percent of inlet pressure up to 15 psig and 42% of absolute (gage pressure + 14.7) inlet pressure above 15 psig inlet.
d) 100 psi saturated steam maximum inlet pressure for heavy duty bronze body globe valves ½"…2".
e) 150 psi saturated steam maximum inlet pressure for high temperature bronze body globe valves ½"…2".
f) 35 psi saturated steam maximum inlet pressure for standard duty bronze body globe valves ½"…2".

d. Valves 3-Way mixing (two inlets and one outlet) NPS 2" and Smaller:

1) Operator, stem and plug assembly, and spring-loaded PTFE/EPDM valve stem packing cartridge must be removable for future replacement to restore the valves back to their original condition. Material grade properties must meet the fluid temperature and pressure requirements:

a) Standard duty bronze body, 316 stainless steel vertical stem, brass plug, and bronze seat, renewable packing cartridge, and screwed or sweat ends. Valves shall have allowable media temperature of 20°F…281°F to assure reliability with dual temperature applications.
b) Heavy duty bronze body, 316 stainless steel vertical stem, 316 stainless steel plug, and 316 stainless steel seat, renewable disc and packing cartridge, and screwed ends. Valves shall have allowable media temperature of 20°F …340°F to assure reliability with dual temperature applications.

e. 3-Way mixing hydronic system globe valves shall have the following characteristics:

1) Rangeability: Greater than 100:1 for all valves to provide stable
2) Maximum Allowable Seat Leakage: A port must be designed to meet ANSI Class V (0.0005 ml per minute per "of orifice diameter per psi differential) up to 35 psi close off differential pressure and ANSI IV seat leakage (maximum 0.01% of full open valve capacity) above 35 psi with appropriate actuator. B port must meet ANSI Class III seat leakage (maximum 0.1% of full open valve capacity).
3) The valve must be able to operate with a full-open operating differential of 87 psi.
4) Flow Characteristics: Modified linear characteristics with gradual opening for light loads.
5) Sizing: Modulating Water: Minimum 5 psi or at least equal to the load pressure drop.

f. Valves 3-Way diverting (one inlet and two outlets) NPS 2" and Smaller:

1) Operator, stem and plug assembly, and spring-loaded PTFE/EPDM valve stem packing cartridge must be removable for future replacement to restore the valves back to their original condition. Valves must be designed specifically for diverting service, and mixing valves designed for mixing service must not be used for diverting applications. Material grade properties must meet the fluid temperature and pressure requirements:

a) Standard duty bronze body, 316 stainless steel vertical stem, brass plug, and bronze seat, renewable disc and packing cartridge, and screwed ends. Valves shall have allowable media temperature of 20°F …281°F to assure reliability with dual temperature applications.

g. 3-Way diverting hydronic system globe valves shall have the following characteristics:

1) Rangeability: Greater than 100:1 for all valves to provide stable control under light load conditions.
2) Maximum Allowable Seat Leakage: ANSI Class III seat leakage (maximum 0.1% of full open valve capacity).
3) Maximum Allowable Pressure Differential: 35 psi in.an open position.
4) Flow Characteristics: Modified linear characteristics with gradual opening for light loads.
5) Sizing:

a) Modulating Water: Minimum 5 psi or at least equal to the load pressure drop.

h. Required Certifications: Pressure Equipment Directive (PED 97/23/EC), RoHS (Restriction of Hazardous Substances) and REACH (Regulation, Evaluation, Authorization, and Restriction of Chemicals), Canadian Registration Number.
i. Valve and Operator: To assure maximum performance and operation of the valve assembly both the valve and the actuator must be tested and approved by the valve manufacturer to assure compatibility of all components and performance to the specifications.
j. Basis of Design: Schneider Electric Venta VB-7000, or BELIMO.

3. Butterfly Valves

a. Valve body are to be polyester coated iron ASTM A126 lug mating with ANSI class 125/150 flanges.
b. Disc Type: Ductile iron nylon 11 coated.
c. Valve Stem:

1) 2…8" 416 stainless steel double D stem.
2) 10…12" 316 stainless steel double D stem.
3) 14" and larger: stainless steel round shaft woodruff key slot.

d. Valve seat:EPDM tongue and groove seat and molded O-ring flange seat
e. Flow Characteristics: Modified equal percentage.

f. Close-Off Pressure Rating: Bubble-tight shutoff (no leakage).
g. Valve fluid temperature rating: -40…250°F 9. Valve will have two (2) inch extended neck (because of heat). 10.Valve must except pneumatic or electric/electronic actuators 11.Valves must have a minimum of a two (2) year warranty.
h. Valve will have two (2) inch extended neck (because of heat).
i. Valve must accept pneumatic or electric/electronic actuators.
j. Valves must have a minimum of a two (2) year warranty.

4. Flanged Valves

a. Bodies: Shall be American Factory fabricated with ASTM A 126 Class B cast iron body material with the pressure class within the maximum pressure and temperature rating of the piping system. (125 body rating with not less than 200 psig at 150°F, decreasing to 169 psig at 281F per ANSA B16.1)
b. Serviceability: 2-Way valve operators, stem and plug assemblies and spring-loaded PTFE/EPDM valve stem packing cartridges must be removable for future replacement to restore the valves back to their original condition.
c. Construction: Material grades must meet the fluid temperature and pressure requirement temperatures of 20°F …281°F to assure reliability throughout all application temperature ranges.
d. Packings: Shall be cartridges suitable for replacement as units withstanding the full operating temperature ranges, including daily and seasonal fluctuations of water, 60% glycol and steam fluids.
e. Characteristics

1) Rangeability: Two way,100:1 and greater for stable control under light load.
2) Shutoff, 2-Way: Leakage allowed: ANSI Class IV (0.01% of max flow)
3) 3-Way: Leakage allowed: ANSI Class III (0.1% of max flow)
4) Flow curves: 2-Way modified equal percentage characteristic.
5) Mixing and Diverting: Linear, modified with gradual opening for light loads.

f. Piping

1) Diverting valves, with the common port at the bottom can be used for mixing.
2) Mixing valves with the common port at the end must not be used for diverting applications.

g. Sizing

1) Two Position Water: Line size or size using a differential pressure of 1 psi.
2) Modulating Water: 5 PSI or twice the load pressure drop
3) Steam, 2-Way: maximum pressure drop across the valve at a maximum flow of 80 percent of inlet pressure up to 15 psig. Above 15 psig inlet, 42% of absolute (gage pressure + 14.7) inlet pressure.

h. Certifications for All Models:Pressure Equipment Directive (PED 97/23/EC), RoHS (Restriction of Hazardous Substances) and REACH (Regulation, Evaluation, Authorization, and Restriction of Chemicals

i. Basis of Design: Schneider Electric VB-8000 and VB-9000 valves, or BELIMO.

Q. Steam Control Valves

1. ½"…2" Steam Service Designed Globe Valve

a. Body material, and pressure class based on maximum pressure and temperature rating of piping system with a body rating of not less than 400 psig at 150°F, 321 psig at 281°F per ANSI B16.15

b. High temperature spring-loaded PTFE/EPDM valve stem packing cartridge must be removable for future replacement to restore the valves back to their original condition. Material grade properties must meet the fluid temperature and pressure requirements:

1) Standard duty bronze body, 316 stainless steel vertical stem, brass plug, soft seal, and bronze seat, renewable packing cartridge, and screwed/sweat/flared ends. Valves shall have allowable media temperature of 20°F …281°F to assure reliability with dual temperature applications.
2) Heavy duty bronze body, 316 stainless steel vertical stem, 316 stainless steel plug, soft seal, and 316 stainless steel seat, renewable packing cartridge, and screwed ends. Valves shall have allowable media temperature of 20°F …340°F to assure to assure reliability with dual temperature applications.
3) High temperature bronze body, 316 stainless steel vertical stem, 316 stainless steel plug, and 316 stainless steel seat, renewable packing cartridge, and screwed ends. Valves shall have allowable media temperature of 20°F …400°F.

c. Two-way fluid system globe valves shall have the following characteristics:

1) Rangeability: Greater than 100:1 for all valves with flow coefficients of 0.4 and higher to provide stable control under light load conditions.
2) Maximum Allowable Seat Leakage: Standard and heavy duty valves must be designed to meet ANSI Class V (0.0005 ml per minute per "of orifice diameter per psi differential) up to 35 psi close off differential pressure and ANSI Class IV seat leakage (maximum 0.01% of full open valve capacity) above 35 psi with appropriate actuator. High temperature valves must meet ANSI Class III seat leakage (maximum 0.1% of full open valve capacity).
3) The valve must be able to operate with a full-open operating differential of no less than 87 psi.
4) Flow Characteristics: Modified equal percentage characteristics for standard duty water applications and modified linear for heavy duty and high temperature steam applications with gradual opening for light loads.
5) Sizing:

a) Pressure drop across steam valve at a maximum flow of 80 percent of inlet pressure up to 15 psig and 42% of absolute (gage pressure + 14.7) inlet pressure above 15 psig inlet.
b) 100 psi saturated steam maximum inlet pressure for heavy duty bronze body globe valves ½"…2".
c) 150 psi saturated steam maximum inlet pressure for high temperature bronze body globe valves ½"…2".

d) 35 psi saturated steam maximum inlet pressure for standard duty bronze body globe valves ½"…2".

6) Certifications for All Models: Pressure Equipment Directive (PED 97/23/EC), RoHS (Restriction of Hazardous Substances) and REACH (Regulation, Evaluation, Authorization, and Restriction of Chemicals).
7) Basis of Design: Schneider Electric VB-7000 valves, or BELIMO.

2. 2-½"…6" Steam Service Designed Globe Valves

a. Bodies: Shall be American Factory fabricated with ASTM A 126 Class B cast iron body material with the pressure class within the maximum pressure and temperature rating of the piping system. (125 body rating with not less than 200 psig at 150°F, decreasing to 169 psig at 281F per ANSA B16.1).
b. Serviceability: 2-Way valve operators, stem and plug assemblies and spring-loaded PTFE/EPDM valve stem packing cartridges must be removable for future replacement to restore the valves back to their original condition.
c. Construction: Material grades must meet the fluid temperature and pressure requirement temperatures of 20°F …281°F to assure reliability throughout all application temperature ranges.
d. Packings: Shall be cartridges suitable for replacement as units withstanding the full operating temperature ranges, including daily and seasonal fluctuations of water, 60% glycol and steam fluids.
e. Characteristics

1) Rangeability: Two way, 100:1 and greater for stable control under light load.
2) Shutoff, 2-Way: Leakage allowed: ANSI Class IV (0.01% of max flow)
3) Flow curves: 2-Way modified equal percentage characteristic.

f. Sizing

1) Steam, 2-Way: maximum pressure drop across the valve at a maximum flow of 80 percent of inlet pressure up to 15 psig. Above 15 psig inlet, 42% of absolute (gage pressure + 14.7) inlet pressure.

g. Certifications for All Models: Pressure Equipment Directive (PED 97/23/EC), RoHS (Restriction of Hazardous Substances) and REACH (Regulation, Evaluation, Authorization, and Restriction of Chemicals.
h. Basis of Design: Schneider Electric VB-8000 and VB-9000 valves, or BELIMO.

R. Control Valve Actuators

1. ½" to ¾" Ball Valve Actuators

a. Size for torque required for valve close-off pressure for system design.
b. Coupling: Direct coupled to valve body without use of external devices/tools
c. Auxiliary End Switch (optional) to be SPST 24 Vac/Vdc, 101 mA to 5 mA maximum on selected two-position models.

d. Controller Signal Two-position, Floating or Proportional (0…5 Vdc, 0…10 Vdc, 5…10 Vdc, or 4…20 mA dc). Design allows for change via DIP switches without removal of cover.
e. Manual operating lever and position indicator must be standard.
f. Power Requirements: 24 Vac for floating, proportional, and 110…230 Vac for two position multi-voltage types
g. Actuators must be available with either Spring Return (SR) or Non-Spring Return (NSR) models.
h. Operating Temperature Limit Floating is to be 32…140°F Proportional 32…140°F Two-Position 32…169°F
i. Wiring (depending on model) Removable Terminal Block, 10 ft. Plenum Cable, 18 in. (45 cm) Appliance Wire
j. Locations must be rated NEMA 2, IEC IP31. (Indoor Use Only.) Actuators with terminal block or plenum cable leads are plenum rated per UL file number E9429.
k. Agency Listings: ISO 9001, cULus, and CE.
l. Basis of Design: Schneider Electric VBB/VBS, or BELIMO.

2. ½" to 3" 2-way and ½" to 2" 3-way Ball Valves Actuators

a. Size for torque required for valve close-off pressure for system design.
b. Actuators are to be available in spring return (SR) and non-spring return (NSR) models. Spring Return (SR) actuators are to provide a choice to return direction.
c. Actuators are to be available in models for two-position, floating and proportional control.
d. All actuator models are to be equipped with pigtail leads, manual override, and auxiliary switch(es)
e. Operating temperatures' Floating Non-Spring Return (NSR) with 33 lb.-in. of torque must be -25 to 130 °F.All other actuators are to -22 to 140 °F
f. Actuators must be NEMA 2 rated.
g. Agency Listings: ISO 9001, cULus, and CE.
h. Basis of Design: Schneider Electric VB-2000, or BELIMO.

3. ½" to 2" Bronze, Linear Globe Valve Actuators/67 or 78 lbs. force

a. Actuator must have bi-color LED status indication for motion indication, auto calibration and alarm notification.
b. When the actuator is properly mounted must have a minimum of a NEMA 2 (IP53) rating.
c. Actuators are to be non-spring return.
d. Actuators are to be floating (used for two-position) or proportional models.
e. Proportional models will have optional models with a position output signal with field selectable 2…10 Vdc and 0…10 Vdc input signals and selectable input signal direct or reverse acting.
f. Actuator must have auto calibration which provides precise control by scaling the input signal to match the exact travel of the valve stem
g. Actuators must come in models with Pulse Width Modulated (PWM) with field selectable 0.59 to 2.93 sec and 0.1 to 25.5 sec input signal ranges with a position output signal
h. Actuators must have manual override with automatic release.
i. Models with position feedback output signal include field selectable 2…10 Vdc or 0…5 Vdc output signal

j. Removable wiring screw terminal with ½" conduit opening.
k. Actuator operating temperature ranges:
    1) When controlling fluid up to 266°F = ambient air temperature is to be 23…131°F
    2) Fluid up to 281°F = 23…127°F
    3) Fluid up to 340°F = 23…115°F
    4) Fluid up to 400°F = 23…102°F
l. Actuator agency Listings: cUL-us LISTED mark, NEMA 2, NEC class 2 FCC part-15 class B, Canadian ICES-003, ESA registered, Plenum rated per UL 20430
m. Basis of Design: Schneider Electric MG350V, or BELIMO.

4. ½" to 2" Bronze, Linear Globe Valve Actuators/105 lbs. force

a. Actuators must have Two- Position, Floating, and Proportional models.
b. Proportional models will a controller input signal of either a 0…10 Vdc, 2…10 Vdc, 4…20 mAdc, 0…3 Vdc, or 6…9 Vdc. Control function direct/reverse action is switch selectable on most models.
c. Actuator force is to be 105 lb.(467 newton) with ½" nominal linear stroke
d. Power requirements 24 Vac, 120 Vac or 230 Vac depending on model.
e. Actuator housings rated for up to NEMA 2/ IP54.
f. Actuator is to have overload protection throughout stroke.
g. Actuator Operating temperature -22…140°F up to a maximum valve fluid temperature of 366°F.
h. Actuator must automatically set input span to match valve travel.
i. Actuator must have manual override to allow positioning of valve and preload.
j. Actuator is to be spring return.
k. Actuator is to mount directly to valves without separate linkage.
l. Actuator agency Listings:UL 873, CUL: UL
m. Basis of Design: Schneider Electric SmartX Mx51-7103, or BELIMO.

5. ½" to 2" Bronze, Linear Globe Valve Actuators/220 lbs. force

a. Actuators must have Two- Position for a SPST controller, Floating for a SPST controller, and Proportional models will a controller input signal of either a 0…10 Vdc, 2…10 Vdc, 4…20 mAdc, or 6…9 Vdc. Control function direct/reverse action is jumper selectable
b. Actuator is to be spring return.
c. Actuator will have 220 lb. force (979 newton) with ½" or 1" nominal linear stroke
d. Feedback on proportional model with 2…10 Vdc (max. 0.5 mA) output signal or to operate up to four like additional slave actuators.
e. Actuator operating temperature is 0…140°F up to a maximum valve fluid temperature of 281°F, 0…120°F up to a maximum valve fluid temperature of 300°F, 0…100°F up to a maximum valve fluid temperature of 340°F, 0…90°F up to a maximum valve fluid temperature of 366°F.
f. Actuator must automatically set input span to match valve travel
g. Actuator is to have a 24 Vac power supply on Two-position and Proportional models and 120 Vac on Two-position models.
h. Actuator housings rated for up to NEMA 2/ IP54
i. Actuator must have manual override to allow positioning of valve and preload
j. Actuator is to mount directly to vales without separate linkage.
k. Actuator agency Listings:UL 873, CUL: UL

l. Basis of Design: Schneider Electric SmartX Mx51-720x, or approved equal.

6. ½" to 2" Bronze, Linear Globe Valve Actuators with linkage SR

a. Actuators with 35, 60, 133, or 150 lb.-in of force depending on model.
b. Actuator housings rated for up to NEMA 2/ IP54 with a 150 lb.-in. rated a NEMA 4.
c. Actuators are to be spring return.
d. Actuators are to have Two-position, Floating and Proportional models.
e. Actuators must have overload protection throughout rotation.
f. Actuator have an optional built-in auxiliary switch to provide for interfacing or signaling on selected models.
g. Actuator agency listings:UL-873, C22-2 No.24-83, CUL0
h. Basis of Design: Schneider Electric SmartX, or BELIMO.

7. ½" to 2" Bronze Body, Linear Globe Valve Actuators with linkage SR & NSR

a. Actuators are to be either floating SPDT control or proportional control 0…10, 2…10 Vdc or 4…20 mA with a 500-ohm resistor included.
b. Actuators are to be direct/reverse with selectable DIP switches.
c. Actuators are to have 90 lb., 180 lb., or 337 lb. of force on Non-Spring Return (NSR) 157 lb. of force on the Spring Return model. Note: Not every actuator is for every valve.
d. Actuators are to be powered with 24 Vac or 24 Vdc.
e. All Non-Spring Return (NSR) actuators are to be NEMA 2, vertical mount only. Spring Return (SR) actuators are to have NEMA 4 models.
f. Actuators must have manual override to allow positioning of the valve.
g. Actuators must have selectable valve sequencing and flow curves of either equal percentage or linear.
h. Actuators must have feedback.
i. Actuators must have internal torque protection throughout stroke.
j. Actuator operating temperature is 14…122°F for chilled water applications, 14…113°F up to a maximum valve fluid temperature of 281°F, 14…107°F up to a maximum valve fluid temperature of 300°F, 14…100°F up to a maximum valve fluid temperature of 340°F, 14…90°F up to a maximum valve fluid temperature of 366°F.
k. Actuator agency listings (North America) UL873, cULus, RCM, CE
l. Basis of Design: Schneider Electric Forta M400A-VB, M800A-VB, M900A and M1500x-VB screw mounted on Venta VB7000s, or BELIMO.

8. 2 ½" to 6" Cast Iron Flanged Globe Valve Linear Actuators with linkage

a. Actuators are to be either floating SPDT control or proportional control 0…10, 2…10 Vdc or 4…20 mA with a 500-ohm resistor included.
b. Actuators are to direct/reverse acting with selectable DIP switch.
c. Actuators are to have 180 lb. or 337 lb. of force.
d. Actuators will need a 24 Vac or Vdc power supply.
e. Actuators are to be rated NEMA 2, vertical mount only.
f. Actuators must have manual override to allow positioning of the valve.
g. Actuators must have selectable valve sequencing and flow curves of either equal percentage to linear. A 2…10 Vac feedback.

h. Actuators must have Internal torque protection throughout stroke.
i. Actuator operating temperature is 14…122°F for chilled water applications, 14…113°F up to a maximum valve fluid temperature of 281°F, 14…107°F up to a maximum valve fluid temperature of 300°F.
j. Actuator agency listings (North America) UL873, cULus, RCM, CE
k. Basis of Design: Schneider Electric Forta M800A and M1500A, or BELIMO.

9. 2-½" to 6" Cast Iron Flanged Globe Valve Actuators/220 lbs. force.

a. Actuators must have Two- Position for a SPST controller, Floating for a SPST controller, and Proportional models will a controller input signal of either a 0…10 Vdc, 2…10 Vdc, 4…20 mAdc, or 6…9 Vdc. Control function direct/reverse action is jumper selectable.
b. Actuator is to be spring return.
c. Actuator will have 220 lb. force (979 newton) with ½" or 1" nominal linear stroke.
d. Feedback on proportional model with 2…10 Vdc output signal or to operate up to four like additional slave actuators.
e. Actuator must automatically set input span to match valve travel.
f. Actuator Operating temperature 0…140°F up to a maximum valve fluid temperature of 300°F.
g. Actuator is to have a 24 Vac power supply on Two-position and Proportional models and 120 Vac on Two-position models.
h. Actuator housings rated for up to NEMA 2/IP54.
i. Actuator must have manual override to allow positioning of valve and preload.
j. Actuator is to mount directly to vales without separate linkage.
k. Actuator agency Listings: UL 873, CUL: UL.
l. Basis of Design: Schneider Electric SmartX Mx61-720x, or BELIMO.

10. 2-½" to 6" Cast Iron Flanged Globe Valve Actuators with linkage SR.

a. Actuators with 60, 133, or 150 lb.-in of force depending on model.
b. Actuator housings rated for up to NEMA 2/ IP54 with a 150 lb.-in. rated a NEMA 4.
c. Actuators are to be spring return.
d. Actuators are to have Two-position, Floating and Proportional models.
e. Actuators must have overload protection throughout rotation.
f. Actuator have an optional built-in auxiliary switch to provide for interfacing or signaling on selected models.
g. Actuator agency listings: UL-873, C22-2 No.24-83, CUL0.
h. Basis of Design: Schneider Electric SmartX, or BELIMO.

11. 2" to 18" 2-Way and 2" to 16" 3-Way Linear Butterfly Valve Actuator with linkage NSR

a. The butterfly valve actuators are to be Non-Spring Return (NSR) two-position and proportional taking 0…10 Vdc or 4…20 mA models.All Actuators are to be NEMA 4, manual override (hand wheel) two auxiliary switches, and built-in heater.
b. Actuator close-offs and CVs must be appropriate for the valve size in a typical HVAC application.
c. Actuators must be available in 24 Vac and 120 Vac models.

d. Actuators must have Internal wiring isolation for parallel wiring multiple units that eliminates the risk of feedback from one actuator to another.
e. Proportional models must have feedback of 0…10 Vdc or 4…20 mA.
f. Actuator operating temperature shall be -40…150°F.
g. Actuator agency listings (North America) UL, CSA and CE
h. Basis of Design: Schneider Electric S70, or BELIMO.

12. 2” to 4” 2-Way and 3-Way Butterfly Valve Actuators SR

a. The butterfly valve actuators are to be Spring Return (SR) two-position and proportional taking 2…10 Vdc or 4…20 mA models.All Actuators are to be NEMA 2.
b. Actuator close-offs and CVs must be appropriate for the valve size in a typical HVAC application.
c. Actuators must be available in 24 Vac models.
d. Actuators shall have two SPDT auxiliary switch models.
e. Actuators must have Internal wiring isolation for parallel wiring multiple units that eliminates the risk of feedback from one actuator to another.
f. Proportional models must have feedback of 2…10 Vdc or 4…20 mA.
g. Actuator operating temperature shall be -22…140°F.
h. Actuator agency listings (North America) UL, CSA and CE
i. Basis of Design: Schneider Electric SmartX Mx-41-7153, or BELIMO.

13. 2” to 6” 2-Way and 3-Way Butterfly Valve Actuators NSR

a. The butterfly valve actuators are to be Non-Spring Return (NSR) two-position and proportional taking 0…10 Vdc or 4…20 mA models.All Actuators are to be NEMA 2.
b. Actuator close-offs and CVs must be appropriate for the valve size in a typical HVAC application.
c. Actuators must be available in 24 Vac models.
d. Actuators shall have two SPDT auxiliary switch models.
e. Actuators must have Internal wiring isolation for parallel wiring multiple units that eliminates the risk of feedback from one actuator to another.
f. Proportional models must have feedback of 2…10 Vdc or 4…20 mA.
g. Actuator operating temperature shall be -4…122°F.
h. Actuator agency listings (North America) UL, CSA and CE
i. Basis of Design: Schneider Electric SmartX NR-22xx-5xx, or BELIMO.

S. Dampers

1. Automatic dampers, furnished by the Building Automation Contractor shall be single or multiple blade as required.Dampers are to be installed by the HVAC Contractor under the supervision of the BAS system supplier.All blank-off plates and conversions necessary to install smaller than duct size dampers are the responsibility of the Sheet Metal Contractor.
2. Damper frames are to be constructed of 13 gauge galvanized sheet steel mechanically joined with linkage concealed in the side channel to eliminate noise as friction.Compressible spring stainless steel side seals and acetyl or bronze bearings shall also be provided.

3. Damper blade width shall not exceed eight inches.Seals and 3/8 inch square steel zinc plated pins are required.Blade rotation is to be parallel or opposed as shown on the schedules.
4. For high performance applications, control dampers will meet or exceed the UL Class I leakage rating.
5. Control and smoke dampers shall be Ruskin, or approved equal.
6. Provide opposed blade dampers for modulating applications and parallel blade for two position control.

T. Damper Actuators

1. Direct-coupled type non-hydraulic designed for minimum 100,000 full-stroke cycles at rated torque.
2. Direct-coupled damper actuators must have a five-year warrantee.
3. Size for torque required for damper seal at maximum design conditions and valve close-off pressure for system design.
4. Direct-coupled damper actuators should accommodate 3/8", ½" 1.05" round or 3/8"…½" and ¾" square damper shafts.
5. Actuator operating temperature minimum requirements: 44, 88 and 133 lb.-in. are –25°F…130°F. The 30, 35, 60, 150 and 300 lb.-in. are -25°…140°F. The 270 are -22°…122°F.
6. Overload protected electronically throughout rotation except for selected Floating actuators the have a mechanical clutch.
7. Spring Return Actuators: Mechanical fail safe shall incorporate a spring-return mechanism.
8. Non-Spring Return Actuators shall stay in the position last commended by the controller with an external manual gear release to allow positioning when not powered.
9. Power Requirements: 24Vac/dc [120Vac][230Vac]
10. Proportional Actuators controller input range from 0…10 Vdc, 2…10 Vdc or 4…20 mA models.
11. Housing: Minimum requirement NEMA type 2with NEMA type 4 available for applications requiring higher ratings.
12. Actuators with a microprocessor should not be able to be modified by an outside source (cracked or hacked).
13. Actuators of 133 and 270 lb.-in. of torque or more should be able to be tandem mount or "gang" mount.
14. Agency Listings: ISO 9001, cULus, CE and CSA
15. Basis of Design: Schneider Electric or BELIMO.

U. Airflow Measuring Stations
Approved Manufatures: Ebtron or Air Monitor

1. Provide a thermal anemometer using instrument grade self heated thermistor sensors with thermistor temperature sensors.
2. The flow station shall operate over a range of 0 to 5,000 feet/min with an accuracy of +/-2% over 500 feet/min and +/- 10 ft/min for reading less than 500 feet/min.

2.7 ELECTRICAL POWER MEASUREMENT

A. Electrical Power Monitors, Single Point (Easy Install):

1. Acceptable Manufacturer: Schneider Electric, Veris Industries.
2. General:Consist of three split-core CTs, factory calibrated as a system, hinged at both axes with the electronics embedded inside the master CT.The transducer shall measure true (rms.RMS) power demand real power (kW) consumption (kWh). Conform to ANSI C12.1 metering accuracy standards.
3. Voltage Input: Load capacity as shown on drawings.208-480 VAC, 60 Hz
4. Maximum Current Input: Up to 2400A
5. Performance:

    a. Accuracy: +/- 1% system from 10% to 100% of the rated current of the CT's
    b. Operating Temperature Range: 32-140°F, 122°F for 2400A.

6. Output: 4 to 20 mA, Pulse. or Modbus RTU
7. Ratings:

    a. Agency: UL508 or equivalent
    b. Transducer internally isolated to 2000 VAC.
    c. Case isolation shall be 600 VAC.

8. Basis of Design: Similar to Enercept H80xx Series, E23 Series
9. Accessories: Current transducers (CTs): split-core (E681/H681/U004) series, solid-core (E682/U004 series) and Rogowski Coils – rope style (E683 series); Communications gateways: Modbus to Ethernet (EGX150)

B. Electrical Power Monitors, Single Point (High Accuracy):

1. Acceptable Manufacturer: Schneider Electric, Veris Industries.
2. General: Revenue grade meter. Measures voltage, amperage, real power (kW), consumption (kWh), and reactive power (kVARar), and power factor (PF) per phase and total load for a single load. Factory calibrated as a system using split core CT's. Neutral voltage connection is required.
3. Voltage Input: 208-480 VAC, 60 Hz
4. Current Input:Up to 2400A
5. Performance:

    a. Accuracy: +/- 1% system from 2% to 100% of the rated current of the CT's
    b. Operating Temperature Range: 32-122°F

6. Output: Pulse, BACnet, Modbus RTU
7. Display: Backlit LCD
8. Enclosure: NEMA 1
9. Agency Rating: UL508 or equivalent
10. Basis of Design: Veris Industries H81xx00 series.
11. Accessories: Current transducers (CTs): split-core (E681/H681/U004) series, solid-core (E682/U004 series)

C. Electrical Power Monitors, Single Point (High Accuracy/Versatility):

1. Acceptable Manufacturer: Schneider Electric, Veris Industries.

2. General: Revenue grade meter. Measures voltage, amperage, real power (kW), consumption (kWh), reactive power (kVAR), apparent power (kVA) and power factor (PF) per phase and total load for a single load. Available with data logging, Bi-directional (4-quadrant) metering, and pulse contact accumulator inputs.
3. Voltage Input: 90-600 VAC, 50/60 Hz, 125-300 VDC
4. Current Input:5A – 32,000A, selectable 1/3V or 1V CT inputs
5. Performance:

    a. Accuracy shall be +/- [0.2%][0.5%] revenue grade
    b. Operating Temperature Range: -22-158°F

6. Output shall be [Pulse][BACnet][Modbus RTU][LON][Modbus TCP][BACnet/IP][Modbus RTU/TCP][SNMP]
7. Display: Backlit LCD
8. Enclosure: NEMA 4x optional
9. Agency Rating: UL508, ANSI C12.20
10. Basis of Design: Veris E50 series, Veris E60 Series or Schneider Electric PM5000 Series
11. Accessories: Current transducers (CTs): split-core (E681/H681/U004) series, solid-core (E682/U004 series) and Rogowski Coils – rope style (E683 series)

D. Electrical Power Monitors, Multiple Point (92 loads, High Accuracy):

1. Acceptable Manufacturer: Schneider Electric, Veris Industries.
2. General: Revenue grade meter. Measures volts, amps, power and energy for each circuit. 1/4 amp to 200 amp monitoring. 4 configurable alarm threshold registers
3. Voltage Input: 90-277 VAC, 60 Hz
4. Current Input:5A – 32,000A, 1/3V CT inputs
5. Performance:

    a. Accuracy: +/- 0.5% meter (split core), +/- 1% system from 1/4-100A (solid core)
    b. Operating Temperature Range: 32-140°F

6. Output: BACnetBACnet/IP
7. Agency Rating: UL508, ANSI C12.10, IEC Class 1
8. Basis of Design: Veris E3xxx series.

PART 3 - EXECUTION

3.1 GENERAL

A. Examine equipment exterior and interior prior to installation. Report any damage and do not install any equipment that is structurally, moisture, or mildew damaged.

B. Verification of Conditions: Examine areas and conditions under which the work is to be installed, and notify the Contractor in writing, with a copy to the Owner and the Engineer, of any conditions detrimental to the proper and timely completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected.

C. Beginning of the work shall indicate acceptance of the areas and conditions as satisfactory by the Installer.

D. Install equipment in accordance with reviewed product data, final shop drawings, manufacturer’s written instructions and recommendations, and as indicated on the Drawings.

E. Provide final protection and maintain conditions in a manner acceptable to the manufacturer that shall help ensure that the equipment is without damage at time of Substantial Completion.

F. Demolition

1. Remove controls which do not remain as part of the building automation system, all associated abandoned wiring and conduit, and all associated pneumatic tubing.The Owner will inform the Contractor of any equipment which is to be removed that will remain the property of the Owner.All other equipment which is removed will be disposed of by the Contractor.

G. Access to Site

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

H. Code Compliance

1. All wiring shall be installed in accordance with all applicable electrical codes and will comply with equipment manufacturer's recommendations.Should any discrepancy be found between wiring specifications in Division 17 and Division 16, wiring requirements of Division 17 will prevail for work specified in Division 17.

I. Cleanup

1. At the completion of the work, all equipment pertinent to this contract shall be checked and thoroughly cleaned, and all other areas shall be cleaned around equipment provided under this contract.

3.2 SYSTEM ACCEPTANCE TESTING

A. All application software will be verified and compared against the sequences of operation.

B. Control loops will be exercised by inducing a setpoint shift of at least 10% and observing whether the system successfully returns the process variable to setpoint.Record all test results and attach to the Test Results Sheet.

C. Test each alarm in the system and validate that the system generates the appropriate alarm message, that the message appears at all prescribed destinations (workstations or printers), and that any other related actions occur as defined (i.e. graphic panels are invoked, reports are generated, etc.).Submit a Test Results Sheet to the owner.

D. Perform an operational test of each unique graphic display and report to verify that the item exists, that the appearance and content are correct, and that any special features work as intended.Submit a Test Results Sheet to the owner.

E. Perform an operational test of each third party interface that has been included as part of the automation system.Verify that all points are properly polled, that alarms have been configured, and that any associated graphics and reports have been completed.If the interface involves a file transfer over Ethernet, test any logic that controls the transmission of the file, and verify the content of the specified information.

3.3 INSTALLATION

A. Hardware Installation Practices for Wiring

1. All controllers are to be mounted vertically and per the manufacturer's installation documentation.
2. The 120VAC power wiring to each Ethernet or Remote Site controller shall be a dedicated run, with a separate breaker.Each run will include a separate hot, neutral and ground wire.The ground wire will terminate at the breaker panel ground.This circuit will not feed any other circuit or device.
3. A true earth ground must be available in the building.Do not use a corroded or galvanized pipe, or structural steel.
4. Wires are to be attached to the building proper at regular intervals such that wiring does not droop.Wires are not to be affixed to or supported by pipes, conduit, etc.
5. Conduit in finished areas will be concealed in ceiling cavity spaces, plenums, furred spaces and wall construction.Exception; metallic surface raceway may be used in finished areas on masonry walls.All surface raceway in finished areas must be color matched to the existing finish within the limitations of standard manufactured colors.
6. Conduit, in non-finished areas where possible, will be concealed in ceiling cavity spaces, plenums, furred spaces, and wall construction.Exposed conduit will run parallel to or at right angles to the building structure.
7. Wires are to be kept a minimum of three (3) inches from hot water, steam, or condensate piping.
8. Where sensor wires leave the conduit system, they are to be protected by a plastic insert.
9. Wire will not be allowed to run across telephone equipment areas.
10. Provide fire caulking at all rated penetrations.

B. Installation Practices for Field Devices

1. Well-mounted sensors will include thermal conducting compound within the well to insure good heat transfer to the sensor.
2. Actuators will be firmly mounted to give positive movement and linkage will be adjusted to give smooth continuous movement throughout 100 percent of the stroke.
3. Relay outputs will include transient suppression across all coils.Suppression devices shall limit transients to 150% of the rated coil voltage.
4. Water line mounted sensors shall be removable without shutting down the system in which they are installed.
5. For duct static pressure sensors, the high pressure port shall be connected to a metal static pressure probe inserted into the duct pointing upstream. The low pressure port shall be left open to the plenum area at the point that the high pressure port is tapped into the ductwork.
6. For building static pressure sensors, the high pressure port shall be inserted into the space via a metal tube. Pipe the low pressure port to the outside of the building.

C. Wiring, Conduit, and Cable

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

    a. Power - 12 Gauge - 600 Volt
    b. Class One - 14 Gauge Std. - 600 Volt
    c. Class Two - 18 Gauge Std. - 300 Volt
    d. Class Three - 18 Gauge Std. - 300 Volt
    e. IP Communications - Per Mfr.

2. Power and Class One wiring may be run in the same conduit.Class Two and Three wiring and communications wiring may be run in the same conduit.
3. Where different wiring classes terminate within the same enclosure, maintain clearances and install barriers per the National Electric Code.
4. Where wiring is required to be installed in conduit, EMT shall be used.Conduit shall be minimum 1/2 inch galvanized EMT.Set screw fittings are acceptable for dry interior locations.Watertight compression fittings shall be used for exterior locations and interior locations subject to moisture.Provide conduit seal-off fitting where exterior conduits enter the building or between areas of high temperature/moisture differential.
5. Flexible metallic conduit (max. 3 feet) shall be used for connections to motors, actuators, controllers, and sensors mounted on vibration producing equipment.Liquid-tight flexible conduit shall be use in exterior locations and interior locations subject to moisture.
6. Junction boxes shall be provided at all cable splices, equipment termination, and transitions from EMT to flexible conduit.Interior dry location J-boxes shall be galvanized pressed steel, nominal four-inch square with blank cover.Exterior and damp location JH-boxes shall be cast alloy FS boxes with threaded hubs and gasketed covers.
7. Where the space above the ceiling is a supply or return air plenum, the wiring shall be plenum rated.Teflon wiring can be run without conduit above suspended ceilings: EXCEPTION: Any wire run in suspended ceilings that is used to control outside air dampers or to connect the system to the fire management system shall be in conduit.
8. Fiber optic cable shall include the following sizes; 50/125, 62.5/125 or 100/140.
9. Only glass fiber is acceptable, no plastic.
10. Fiber optic cable shall only be installed and terminated by an experienced contractor.The BAS system supplier shall submit to the Engineer the name of the intended contractor of the fiber optic cable with his submittal documents.

D. Enclosures

1. For all I/O requiring field interface devices, these devices where practical will be mounted in a field interface panel (FIP).The Contractor shall provide an enclosure which protects the device(s) from dust, moisture, conceals integral wiring and moving parts.
2. FIPs shall contain power supplies for sensors, interface relays and contactors, and safety circuits.
3. The FIP enclosure shall be of steel construction with baked enamel finish; NEMA 1 rated with a hinged door and keyed lock.The enclosure will be sized for twenty percent spare mounting space.All locks will be keyed identically.
4. All wiring to and from the FIP will be to screw type terminals.Analog or communications wiring may use the FIP as a raceway without terminating.The use of wire nuts within the FIP is prohibited.
5. All outside mounted enclosures shall meet the NEMA-4 rating.

6. The wiring within all enclosures shall be run in plastic track.Wiring within controllers shall be wrapped and secured.

E. Identification

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

F. Existing Controls.

1. Existing controls which are to be reused must each be tested and calibrated for proper operation. Existing controls which are to be reused and are found to be defective requiring replacement, will be noted to the Owner.The Owner will be responsible for all material and labor costs associated with their repair.

G. Location

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

H. Software Installation

1. The Contractor shall provide all labor necessary to install, initialize, start-up and debug all system software as described in this section.This includes any operating system software or other third party software necessary for successful operation of the system.

3.4 TRAINING

A. The BAS system supplier shall provide both on-site and classroom training to the Owner’s representative and maintenance personnel per the following description:

B. On-site training shall consist of a minimum of (60) hours of hands-on instruction geared at the operation and maintenance of the systems. The curriculum shall include

1. System Overview
2. System Software and Operation
3. System access
4. Software features overview
5. Changing setpoints and other attributes

6. Scheduling
7. Editing programmed variables
8. Displaying color graphics
9. Running reports
10. Workstation maintenance
11. Viewing application programming
12. Operational sequences including start-up, shutdown, adjusting and balancing.
13. Equipment maintenance

3.5 CONTROL SYSTEM SWITCH-OVER

A. Demolition of the existing control system will occur after the new temperature control system is in place including new sensors and new field interface devices.

B. Switch-over from the existing control system to the new system will be fully coordinated with the Owner.A representative of the Owner will be on site during switch-over.

C. The Contractor shall minimize control system downtime during switch-over.Sufficient installation mechanics will be on site so that the entire switch-over can be accomplished in a reasonable time frame.

3.6 DATABASE CONFIGURATION.

A. The Contractor will provide all labor to configure those portions of the database that are required by the points list and sequence of operation.

3.7 COLOR GRAPHIC DISPLAYS.

A. Unless otherwise directed by the owner, the Contractor will provide color graphic displays as depicted on existing system as it applies. Any equipment graphics that are not existing as an example shall be created as close to examples as can be, including complete floorplans for each building. The display shall contain the associated points identified in the point list and allow for setpoint changes as required by the owner.

3.8 REPORTS.

A. The Contractor will configure a minimum of 4 reports for the owner.These reports shall, at a minimum, be able to provide:

1. Trend comparison data
2. Alarm status and prevalence information
3. Energy Consumption data (if applicable)
4. System user data

3.9 POINT TO POINT CHECKOUT.

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

B. In case of wireless devices, the signal strength recorded during checkout shall be reported.

3.10 CONTROLLER AND WORKSTATION CHECKOUT.

A. A field checkout of all controllers and front end equipment (computers, printers, modems, etc.) shall be conducted to verify proper operation of both hardware and software.A checkout sheet itemizing each device and a description of the associated tests shall be prepared and submitted to the owner or owner's representative by the completion of the project.

3.11 DOCUMENTATION

A. As built software documentation will include the following:

1. Descriptive point lists
2. Application program listing
3. Application programs with comments.
4. Printouts of all reports.
5. Alarm list.
6. Printouts of all graphics
7. Commissioning and System Startup
8. An electronic copy of all databases, configuration files, or any type of files created specifically for each system.

END OF SECTION

SECTION 15985 – SEQUENCE OF OPERATION

1.1 SEQUENCE OF OPERATION

A. The new controls shall be an extension of the time control system.

B. Boilers B-1, & B-2 and Pumps BP-1 & BP-2.

1. The hot water boilers and pumps shall operate continuously. Boilers shall be staged. Boilers shall alternate weekly for lead-lag. The combustion air damper shall open when the boiler starts
2. The boiler discharge water temperature shall be reset as follows:

    a. 0°F outside, 180°F HWS.
    b. 60°F outside, 100°F HWS.

3. Provide an emergency shut-off and alarm for all boilers outside/inside of all entrance doors.
4. P-1 & 2 shall be supplied with VFD's. The VFD's shall modulate to maintain set system pressure. Locate sensors on the second floor.

END OF SECTION

SECTION 15990 - TESTING, ADJUSTING AND BALANCING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section specifies the requirements and procedures for total mechanical systems testing, adjusting and balancing. Requirements include measurement and establishment of the fluid quantities of the mechanical systems as required to meet design specifications, and recording and reporting the results.

B. Test, adjust, and balance the following new mechanical systems:

1. Supply air systems, all pressure ranges.
2. Return air systems.
4. Hydronic systems.
5. Verify temperature control system operation.

C. Test, adjust and balance existing systems to the extent required to assure proper operation of all new equipment (or as indicated).

1. Balance the following existing systems:

   a. Supply air systems, all pressure ranges.
   b. Return air systems.
   c. Hydronic systems.
   d. Verify existing temperature control system operation.

2. Read total fluid flow to all existing equipment before and after balance of existing systems to verify that flow to existing equipment has not changed.
3. Existing pumps and fans shall be sped up as required, including sheave changes, to achieve required flow to all new and existing equipment.
4. Report to Architect/Engineer any discrepancies found.

D. Test systems for proper sound and vibration levels.

E. This Section does not include:

1. Testing boilers and pressure vessels for compliance with safety codes.
2. Specifications for materials for patching mechanical systems.
3. Specifications for materials and installation of adjusting and balancing devices. If devices must be added to achieve proper adjusting and balancing, refer to the respective system sections for materials and installation requirements.
4. Requirements and procedures for piping and ductwork systems leakage tests.

1.2 SUBMITTALS

A. Certified Reports: Submit testing, adjusting and balancing reports bearing the seal and signature of the Test and Balance Engineer.

The reports shall be certified proof that the systems have been tested, adjusted and balanced in accordance with the referenced standards; are an accurate representation of how the systems have been installed; are a true representation of how the systems are operating at the completion of the testing, adjusting and balancing procedures; and are an accurate record of all final quantities measured, to establish normal operating values of the systems. Follow the procedures and format specified below:

1. Draft reports: Upon completion of testing, adjusting and balancing procedures, prepare draft reports on the approved forms. Draft reports may be hand written, but must be complete, factual and legible. Organize and format draft reports in the same manner specified for the final reports. Submit two complete sets of draft reports. Only one complete set of draft reports will be returned.
2. Final Report: Upon verification and approval of draft reports, prepare final reports, type written, and organized and formatted as specified below. Submit two complete sets of final reports.
3. Report Format: Report forms shall be those standard forms prepared by the referenced standard for each respective item and system to be tested, adjusted and balanced. Bind report forms complete with schematic systems diagrams and other data in reinforced, vinyl, three-ring binders. Provide binding edge labels with the project identification and a title descriptive of the contents. Divide the contents of the binder into the below listed divisions, separated by divider tabs:

    a. General Information and Summary
    b. Air Systems
    c. Hydronic Systems
    d. Temperature Control Systems
    e. Special Systems
    f. Sound and Vibration Systems

4. Report Contents: Provide the following minimum information, forms and data:

    a. General Information and Summary: Inside cover sheet to identify testing, adjusting and balancing agency, Contractor, Owner, Architect, Engineer and Project. Include addresses and contact names and telephone numbers. Also include a certification sheet containing the seal and name, address, telephone number and signature of the Certified Test and Balance Engineer. Include in this division a listing of the instrumentations used for the procedures along with the proof of calibration.
    b. The remainder of the report shall contain the appropriate forms containing, as a minimum, the information indicated on the standard report form prepared by the AABC and NEBB, for each respective item and system. Prepare a schematic diagram for each item of equipment and system to accompany each respective report form.

B. Calibration Reports: Submit proof that all required instrumentation has been calibrated to tolerances specified in the referenced standards, within a period of six months prior to starting the project.

1.3 QUALITY ASSURANCE

A. Agency Qualifications:

1. Employ the services of an independent testing, adjusting and balancing agency meeting the qualifications specified below, to be the single source of responsibility to test, adjust and balance the building mechanical systems identified above to produce the design objectives. Services shall include checking installations for conformity to design, measurement and establishment of the fluid quantities of the mechanical systems as required to meet design specifications, and recording and reporting the results.
2. An independent testing, adjusting and balancing agency certified by Associated Air Balance Council (AABC) in those testing and balancing disciplines required for this project, and having at least one Professional Engineer registered in the state in which the services are to be performed, certified by AABC as a Test and Balance Engineer.

B. Codes and Standards:

1. AABC: National Standards for Total System Balance.
2. NEBB: Procedural standard for testing, adjusting, and balancing of environmental systems.
3. ASHRAE: ASHRAE Handbook, 1984 Systems Volume, Chapter 37, Testing, Adjusting and Balancing.

C. Pre-Balancing Conference: Prior to beginning of the testing, adjusting and balancing procedures, schedule and conduct a conference with the representatives of installers of the mechanical systems. The objective of the conference is final coordination and verification of system operation and readiness for testing, adjusting and balancing.

1.4 PROJECT CONDITIONS

A. Systems Operation: Systems shall be fully operational prior to beginning procedures.

1.5 SEQUENCING AND SCHEDULING

A. Test, adjust and balance the air systems before hydronic and refrigerant systems.

B. Test, adjust and balance air conditioning systems during summer season and heating systems during winter season, including at least a period of operation at outside conditions within 5 degrees F wet bulb temperature of maximum summer design condition, and within 10 degrees F dry bulb temperature of minimum winter design condition. Take final temperature readings during seasonal operation.

PART 2 - PRODUCTS

(Not Used)

PART 3 - EXECUTION

3.1 PRELIMINARY PROCEDURES FOR AIR SYSTEM BALANCING

A. Before operating the system, perform these steps:

1. Obtain design drawings and specifications including addendums and bulletins and become thoroughly acquainted with the design intent.

2. Obtain copies of approved shop drawings of all air handling equipment, outlets (supply, return and exhaust) and temperature control diagrams.
3. Compare design to installed equipment and field installations.
4. Walk the system from the system air handling equipment to terminal units to determine variations of installation from design.
5. Check filters for cleanliness.
6. Check dampers (both volume and fire) for correct and locked position, and temperature control for completeness of installation before starting fans.
7. Prepare report test sheets for both fans and outlets. Obtain manufacturer's outlets factors and recommended procedures for testing. Prepare a summation of required outlet volumes to permit a crosscheck with required fan volumes.
8. Determine best locations in main and branch ductwork for most accurate duct traverses.
9. Place outlet dampers in the full open position.
10. Prepare schematic diagrams of system as-built ductwork and piping layouts to facilitate reporting.
11. Lubricate all motors and bearings.
12. Check fan belt tension.
13. Check fan rotation.

3.2 PRELIMINARY PROCEDURES FOR HYDRONIC SYSTEM BALANCING

A. Before operating the system, perform these steps:

1. Open valves to full open position. Close coil bypass valves.
2. Remove and clean all strainers.
3. Examine hydronic systems and determine if water has been treated and cleaned.
4. Check pump rotation.
5. Clean and set automatic fill valves for required system pressure.
6. Check expansion tanks to determine that they are not air bound and that the system is completely full of water.
7. Check air vents at high points of systems and determine if all are installed and operating freely (automatic type) or to bleed air completely (manual type).
8. Set temperature controls so all coils are calling for full flow.
9. Check operation of automatic bypass valves.
10. Check and set operating temperatures of chillers to design requirements.
11. Lubricate all motors and bearings.

3.3 MEASUREMENTS

A. Provide all required instrumentation to obtain proper measurements, calibrated to the tolerances specified in the referenced standards. Instruments shall be properly maintained and protected against damage.

B. Provide instruments meeting the specifications of the referenced standards.

C. When averaging values, take a sufficient quantity of readings which will result in a repeatability error of less than 5 percent. When measuring a single point, repeat readings until two consecutive identical values are obtained.

D. Take measurements in the system where best suited to the task.

3.4 PERFORMING TESTING, ADJUSTING AND BALANCING

A. Perform testing and balancing procedures on each system identified, in accordance with the detailed procedures outlined in the referenced standards.

B. Cut insulation and patch, ductwork and piping for installation of test probes to the minimum extent necessary to allow adequate performance of procedures.

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

D. Retest, adjust and balance systems subsequent to significant system modifications, and resubmit test results.

3.5 TOLERANCES

A. Set HVAC system airflow and water flow rates within the following tolerances:

1. Supply, Return, and Exhaust Fans: 0 to plus 10 percent.
2. Air Outlets and Inlets: Plus 10 to minus 10 percent
3. Water Flow Rate: Plus 10 to minus 10 percent.

3.6 TESTING FOR SOUND AND VIBRATION

A. Test and adjust mechanical systems for sound and vibration in accordance with the detailed instructions of the referenced standards.

3.7 RECORD AND REPORT DATA

A. Record all data obtained during testing, adjusting and balancing in accordance with and on the forms recommended by the referenced standards, and as approved on the sample report forms.

B. Prepare report of recommendations for correcting unsatisfactory mechanical performances when system cannot be successfully balanced.

3.8 DEMONSTRATION

A. Training:

1. Train the Owner's maintenance personnel on troubleshooting procedures and testing, adjusting and balancing procedures. Review with the Owner's personnel, the information contained in the Operating and Maintenance Data specified in Division 1 and Section 15010.
2. Schedule training with Owner through the Architect/Engineer with at least seven days prior notice.

END OF SECTION

DIVISION 16 - ELECTRICAL

INDEX SHEET

SECTION 16000 – ELECTRICAL GENERAL PROVISIONS

SECTION 16050 – BASIC ELECTRICAL MATERIALS AND METHODS

SECTION 16060 – GROUNDING AND BONDING

SECTION 16075 – ELECTRICAL IDENTIFICATION

SECTION 16120 – CONDUCTORS AND CABLES

SECTION 16130 – RACEWAYS AND BOXES

Applicable provisions of Bidding Requirements,
Project Guidelines and General Requirements (Division 1)
apply to the work specified in these Sections.

SECTION 16000 – ELECTRICAL GENERAL PROVISIONS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

Applicable provisions of Bidding Requirements, Project Guidelines and General Requirements (Div. 1) apply to work specified in this Section.

1.2 DESCRIPTION

A. Work Included:

1. This Section includes all labor, materials, equipment, tools, supervision, start-up services, and Owner's instructions, including all incidental and related items necessary to complete installation and successfully test, start-up and operate in a practical and efficient manner, all electrical work and systems indicated on the drawings and described in each Section of Division 16 and conforming with all contract documents.
2. This Section defines certain terms used in these specifications and explains the language, abbreviations thereof, format and certain conventions used in the specifications and certain associated contract documents.
3. The following are not intended to supersede but to clarify the definitions used in the General Requirements (Division 1).

B. Provide temporary facilities in accordance with Division 1.

C. Site and Contract Document Examination: Submission of a Bid Proposal is considered to be evidence that the Contractor has visited the site, examined the drawings and specifications of all the trades and has fully informed himself as to all project and site conditions and is proficient, experienced and knowledgeable of all standards, codes, ordinances, permits and regulations which affect every trade's completion, cost and time required and that all costs are included in his Bid Proposal.

D. Responsibility:

1. The Contractor shall be responsible for all subcontractors and suppliers and shall include in his bid and apportion all materials, labor and equipment to the several trades involved in accordance with all local customs, rules, regulations, jurisdictional awards, decisions, and secure compliance to all parts of the specifications and drawings regardless of sectional inclusion in these specifications.
2. Each electrical subcontractor and sub-subcontractor shall be responsible for all parts applicable to his trade in accordance with the specifications and drawings and for coordinating locations and arrangements of his work with all other relevant specifications, drawings, shop drawings and details.

E. Drawings and Specifications:

1. Drawings and specifications and intended to supplement each other and all work specified or indicated on/in either shall be provided.
2. Drawings are diagrammatic and indicate general arrangements of systems and work included in the contract and shall serve only as design drawings and not as working drawings for general layout of various equipment and systems.

Drawings do not necessarily indicate every required offset, junction box, pull box, mounting support, access panel, etc. which shall be provided as required.

3. Each subcontractor shall examine all drawings and specifications of his trade and drawings, shop drawings and field layouts of work of all other trades working on the project, including architectural, structural and mechanical. If any discrepancies occur between these various drawings or between these drawings and these specifications, he shall report same to the Engineer in writing and shall obtain written instructions for changes in construction.

   Should interferences develop during construction which cannot be avoided, the Engineer shall decide which work is to be relocated regardless of which was first installed. This work shall be performed at no extra cost to the Owners.

4. Should drawings disagree in themselves or with the specifications, the better quality or greater quantity of work shall be provided.
5. All schedules on the drawings or in the specifications are only for the convenience of the Contractor. The Contractor shall make his own count and, where fixtures and/or equipment are indicated on the drawings but not in the schedules, the Contractor shall provide like equipment and/or fixtures as are indicated for like rooms or used elsewhere on the project.
6. Manufacturer's Model Numbers:

   a. Wherever, on the drawings or specifications, that a manufacturer's catalog number of model or type designation is made, it is intended as a general qualification. It shall remain the Contractor's responsibility, before the ordering of any material, to determine the proper type or model with arrangement, mounting and accessories applicable for each location on the project.
   b. Approval of shop drawings by the Engineer does not obviate the Contractor's responsibility.

7. Drawings shall not be scaled for measurements and shall not serve as shop drawings.

F. Definitions:

1. Furnish: Supply and deliver to the project site, ready for unloading, unpacking, assembly, installation and similar subsequent requirements.
2. Install: Operations at the project site, including unloading, unpacking, assembly, erection, placing, anchoring applying, working to dimension, finishing, protection, cleaning and similar requirements.
3. Provide: Furnish and install, complete and ready for the intended use.
4. Minimum Requirements:

   a. Indicated requirements are for a specific minimum acceptable level of quality as recognized in the industry. Actual work must comply, within specified tolerances, or may exceed minimums within reasonable limits.
   b. Refer uncertainties to the Engineer for decisions before proceeding.

5. Abbreviations and Plural Words:

   a. Abbreviations, where not defined in the contract documents, will be interpreted to mean the normal construction industry terminology determined by recognized grammatical rules by the Engineer.

b. Plural words will be interpreted as singular and singular words will be interpreted as plural where applicable for the context of the contract documents.

6. Raceway: Conduit, wireway, channels, boxes, fittings, hangers, supports and items necessary or required in connection with and/or relating to raceway to provide a complete installation.
7. Concealed: Embedded in masonry or other construction below floor slabs, installed behind wall finishes, within double partitions or above hung ceilings, in trenches, tunnels or crawl spaces.
8. NIC: Items and/or areas shown on the drawings or identified within these specifications with "NIC" shall be considered by this Contractor as "Not In Contract". As a result, this Contractor shall take no action on those items identified as such.

G. Substitutions and Changes:

1. When a material, method or product is listed, shown or scheduled by trade name or catalog number for a use, it shall be the basis of design. Other "similar" manufacturers may or may not be listed as "acceptable", provided that the specific item is comparable with the basis and intent of the design.
2. Contractors shall base their bid proposals only on those items either:

a. Originally named, listed, shown or specified on/in the drawings/specifications.
b. Named, listed, and/or shown in an official addendum to the drawings/specifications. All other manufacturers or catalog numbers shall be bid as a voluntary alternate only. Any Contractor choosing to base his bid proposal on any item and/or system not either originally named or named in an official addendum as "acceptable" does so at his own risk and may be required to furnish and install the originally named product and, if applicable, bear all of the costs involved with removing the unauthorized product.

3. Contractor shall be considered liable for all added costs both to himself and to others (including those costs as incurred by the Engineer for redesigning or redrawings) resultant from the substitution of products not originally specified.
4. Contractor shall be responsible for the verification of adequate space (considering dimensions, required clearances, weights and roughing-in requirements) for the installation of any items or systems not originally specified. He shall be responsible for the timely advising of all other trades. He shall submit revised drawing layouts for the approval of the Engineer and shall not proceed without this approval.

1.3 STANDARDS, CODES AND PERMITS

A. General: Compliance with standards, codes and permits shall be in accordance with General and Supplemental Conditions.

B. Electrical Work: All work installed under Division 16 shall comply with the latest published edition of the applicable standards and codes of the following:

ASA....American Standards Association
ASTM...American Society for Testing Materials
ANSI...American National Standards Institute
NFPA...National Fire Protection Association
UL.....Underwriter's Laboratories, Inc.

NEMA...National Electrical Manufacturer's Association
NESC...National Electric Safety Code
OSHA...Occupational Safety and Health Act
BOCA...Building Officials and Code Administrators
UBC....Uniform Building Codes
NEC....National Electrical Code
NECA...National Electrical Contractor's Association
NEMA...National Electrical Manufacturer's Association

C. All labor, material and equipment shall comply with all applicable:

1. City, county and state laws, ordinances, codes and regulations.
2. Applicable rules and regulations as required by the Department of Consumer and Industry Services Fire Safety Division.

D. Excess Quantities and Sizes: Where quantities, sizes or other requirements on drawings or in specifications are in excess of code requirements, drawings or specifications shall govern and the specified item or system shall be furnished and installed.

E. Conflicts: Where conflicts are discovered to exist between referenced standards or specifications, the more stringent requirements shall govern. No extra compensation for such compliance will be allowed.

F. Notices and Payments: The Electrical Contractor shall give all notices, file all drawings, obtain all necessary approvals, obtain all permits, pay all fees, deposits and expenses required for installation of all work under this contract. Within ten (10) days after award of the contract, the Contractor shall show proof that such permits have been obtained and appropriate fees paid.

G. Inspections and Certificates of Inspection:

1. No work shall be covered or enclosed until work is tested in accordance with applicable codes and regulations and successful test witnessed and approved by authorized inspection authority.
2. Provide for the Engineer's review evidence that the installation has been inspected and approved by the authorized governmental inspector having jurisdiction over that phase or system of work involved.

H. UL Labels: In general, all material used on this project shall be labeled or listed by Underwriter's Laboratories, Inc.

1.4 SUBMITTALS

A. General: Submittals shall be in accordance with Division 1.

B. Shop Drawings:

1. After the schedules of equipment and Subcontractors are submitted and approved, submit shop drawings covering all equipment, systems and materials to be furnished and installed on this project.

2. Shop drawing submittals shall at the time they are submitted to the Engineer for review, include signatures or stamps of Contractor (and Subcontractor, where applicable) certifying that he/they has/have inspected submittals and have coordinated required space, services and work of other trades for the equipment or system being submitted.
3. Submit complete manufacturer's shop drawings of all equipment, accessories and controls, including (but not limited to) weights, dimensions, capacities, construction details, installation and maintenance instructions, wiring diagrams, available finishes, all applicable manufacturer's warranties and all details involving other trades.
4. General catalog cuts without detailed engineering and installation details will not be accepted.
5. Submittal sheets containing or showing items not applicable to the specific project must be clearly marked to show the equipment or system being submitted. Sheets not so marked will be returned unreviewed.
6. Submittals on items or systems clearly belonging together (such as lighting fixtures) shall be submitted as a booklet or grouping, with each "set" containing components arranged in a logical sequence. The Engineer will not assemble such booklets but will rather return unsorted submittals unreviewed. Submittals shall be maximum size of 36" x 24".
7. Engineer's review of shop drawing submittals is a free service to the Contractor only and, as such, shall not be construed to be a guarantee of compliance with or a relief of the required compliance with the basic responsibilities of the Contractor under the contract documents. Review of submittals shall not be considered to be an approval of changes in time or cost.
8. After review, the Contractor shall provide information to all affected trades.

C. Extra Copies of Submittals: Refer to "Final Acceptance, Guarantees and Warranties" later in this Section for requirements of extra copies of shop drawings and operating and maintenance information.

1.5 DELIVERY, STORAGE, AND HANDLING

A. General: Delivery, storage, and handling shall be in accordance with the General and Supplementary General Conditions.

B. Inspection: Inspect all items upon delivery and remove and replace all items impossible to repair so that they are equal and indistinguishable from new items.

C. Protection: Protect electrical materials and products and installation work against dirt, water, or mechanical damage before, during, and after installation.

D. Repairs: All damage inflicted prior to date of final acceptance shall be repaired or replaced in a manner acceptable to the Engineer at no cost to the Owner by the Contractor or Subcontractor whose work is involved.

1.6 STANDARDS

A. General:

1. All electrical material, equipment, and accessories installed under this project shall be new and shall conform to all applicable standards, requirements, and codes and all applicable local, state, and federal specifications.
2. All products shall be of established manufacturers regularly engaged in the making of the type of materials to be provided.

All products shall be complete with all parts, accessories, supports, trims, connections, etc., reasonably incidental to the product and necessary for installation.

3. All products shall be properly tested, cleaned, adjusted, and put in complete working order ready for service before acceptance will be considered.
4. All electrical work shall be installed in a first-class workmanlike manner.
5. Due to the difficulty in showing the exact locations on the drawings of all raceways, offsets, boxes, fittings, or accessories, coordinate the installation with all trades and, where conflicts occur, obtain the Engineer's approval before installation. Failure to do this shall result in rework to meet the Engineer's approval at no additional cost to the Owner's or Engineer's
6. All conductor and raceway sizes shall meet National Electrical Code (NEC) requirements.

1.7 INSPECTION AND PREPARATION

A. General:

1. Perform inspections in accordance with Division 1, Coordination and Inspections.
2. Prior to starting his work, the Electrical Contractor shall:

    a. Examine all conditions of all areas in which his work is to be installed.
    b. Verify all dimensions indicated of the drawings.
    c. Make all field measurements required for his work.
    d. Report, in writing to the Engineer, any and all discrepancies or required corrections.

3. Do not proceed with the work until acceptable conditions have been provided.
4. The commencement of work by the Electrical Contractor shall signify the Electrical Contractor's acceptance of all existing conditions.

B. Laying Out of the Work:

1. Lay out work and be responsible for lines, elevations, and measurements for installation of the work. Construct work in conformity with lines and elevations as indicated on the drawings.
2. Record all data on project record documents set.

1.8 BASIC INSTALLATION METHODS

A. Equipment Clearance: Coordinate mechanical and electrical equipment locations to ensure that adequate clearance for installation, inspection, and required service is provided. Ensure that adequate clearance is maintained around equipment as required by the National Electrical Code and all applicable state and local codes.

B. General Supports: Provide all necessary angles, channels, brackets, or Unistrut supplementary steel as required for adequate support of all raceway, specialties, and equipment which is hung or mounted above the floor. Secure written approval from the Engineer before welding or bolting to steel framing or anchoring to concrete structure.

C. Equipment Housekeeping Pad Foundations:

1. Unless specifically stated by others, this contractor shall provide concrete housekeeping pad foundations for all floor-mounted equipment whether indicated on the drawings and/or templates and shall locate each pad dimensionally when the pad is provided by others.

2. When provided, pads shall be 3-1/2" high, reinforced with woven wire mesh, level at the top, with each exposed edge chamfered, with dowels into the building floor and required anchor bolts for the equipment designed to rest upon the pad.

D. Wall, Floor, and Ceiling Openings:

1. Place all sleeves and advise affected trades of details and templates of all openings necessary for the installation of the electrical work.
2. Cracks and rough edges left following installation of the equipment shall be caulked, covered, or repaired to the satisfaction of the Engineer.
3. Do not locate any sleeves in any structural member without written approval of the Engineer. Use rotary type drilling tools and concrete cutting saws to cut concrete and masonry walls. Do not use torches for cutting steel.
4. Where piping or equipment is suspended from a metal deck, use "Ramset" or "Hilti" equipment as required.
5. Floor sleeves shall be rigid galvanized steel conduit with the bottom end flush and caulked with glass wool; sealed at the top and bottom.
6. Wall sleeves shall be the same as floor sleeves except that they shall be installed so as to be flush on both sides of the wall.
7. All sleeves shall have an inside diameter one (1) inch larger than the outside diameter of the raceway passing through them.
8. Where exposed pipes pass through floors, walls, or ceilings, this contractor shall be responsible for repairs and finish of all holes placed.
9. All conduits penetrating through slabs shall be waterproofed and sealed to prevent the transfer of water. Use a grout mixture to seal the concrete or "Duxseal" to seal the sleeves.
10. Where conduits and sleeves pass through fire rated partitions, floors, and/or walls, the space between the pipe and the sleeve shall be sealed with an approved material and system such as 3M Fire Barrier Penetration Sealing system as manufactured by the Electro-Products Division/3M, St. Paul, MN 55144.

E. Cutting and Patching:

1. Cutting and patching shall be in accordance with Division 1, Cutting and Patching, and this section.
2. Cutting and patching required by the installing Contractor or Subcontractor shall be performed by the installer under the direct supervision of the General Contractor. Patching shall be, in general, to the same standards of finish and appearance as the adjacent undisturbed material.

   Should it be necessary to achieve this condition, the installer shall employ those specialty workmen as may be required at no additional cost to the Owners.

F. Access Panels:

1. Items of equipment which require accessibility, adjustment, maintenance, or observation such as junction boxes, controls, etc., shall be located and arranged for ready access either directly or through the use of access doors.
2. Notify the Engineer and all affected trades where and of what size and/or configuration access doors will be installed. Secure the approval of the Engineer for these locations and configurations.
3. Such access doors/panels shall meet or exceed the fire barrier rating of the floor, wall, or partition into which they are inserted.

4. Access doors or panels, where required, shall be provided by the Contractor or Subcontractor whose equipment requires the access.

G. Protection:

1. Each Contractor or Subcontractor shall protect his work, fixtures, equipment, and materials at all times and be responsible for all damages caused either directly or indirectly by his workmen or by project conditions.
2. All raceway openings shall be kept tightly closed with caps or plugs (not paper) during installation whenever openings are left unattended.

H. General Cleaning:

1. It shall be the duty of this Contractor to keep the premises free of accumulations of surplus material or rubbish caused by his operations and/or the operations of his Subcontractors. Combustible rubbish and debris shall be removed immediately. The trades shall remove their rubbish and debris from the project site promptly upon its accumulation; in no event later than the Friday of each week.
2. Upon completion of the installation, the Contractor shall thoroughly clean all fixtures, equipment, boxes, and raceways.
3. All patching, repairing, and painting required of surfaces damaged or allowed to deteriorate in the performance of this work made by this Contractor, where directed by the Engineer, at this Contractor's expense.
4. If a Contractor does not remove rubbish or clean the systems as specified above, the Construction Manager reserves the right to have the work performed by others, with the cost back-charged to the Contractor who made the removal or cleaning necessary.
5. Clean all fixtures, boxes, controls, devices, cabinet interiors, enclosures, and other applicable equipment and accessories free of all foreign material.

1.9 FINAL ACCEPTANCE, GUARANTEES AND WARRANTIES

A. General: Final acceptance of the systems, guarantees and warranties shall be in accordance with General Conditions (Division 1), this section and other applicable sections.

B. Final Acceptance: Final acceptance of the systems will be made only after final punch list completion and receipt at the Engineer's office of:

. All guarantees and/or warranties.
. Operating and maintenance instructions.
. Record drawings.
. Certificates of Inspection.
. Test reports.
. Health Department approval.
. Required affidavits for State Fire Marshal.

C. Guarantees and Warranties: Guarantees shall be in accordance with the applicable specification section and the following:

1. All labor, materials and equipment shall be guaranteed by the Contractor and/or warranted by the manufacturer for one (1) calendar year after date of final acceptance, except where specific, longer periods are specified. Contractor shall secure such warranties from all suppliers.

2. Acceptance data of substantial completion or Owner occupancy shall be as determined by Engineer. See "General Requirements" Division 1.
3. Make all necessary alterations, repairs, adjustments and replacements during guarantee period as directed by Engineer to comply with drawings and specifications. Such work shall be at no cost to the Owner.
4. Repair or replacements made under guarantee shall bear one (1) year extended guarantee from date of acceptance of repair or replacement.

D. Operating and Maintenance Instructions and Manuals:

1. Submit to the Engineer operating and maintenance instructions, including the following:

   a. Periodic maintenance items.
   b. Seasonal maintenance items.
   c. Preventative maintenance items.
   d. List of service agents for all major equipment.
   e. List of suppliers for replacement/service parts.

2. Provide the service of factory-trained personnel for such period(s) of time as required to instruct and train the Owner's personnel in the operation and maintenance procedures for all major pieces of equipment, i.e., dimming systems, variable speed drives, etc.
3. Provide instructions to the Owner on locations of hand valves, fire dampers and other concealed or partially concealed items, etc.
4. Provide instructions to the Owner on the location and function of all control devices, fuses, disconnects, etc.
5. A letter from the installing Contractor, certified by the Owner, shall be submitted to the Engineer when all instructions have been given.

E. Operating Personnel and Maintenance: This Contractor shall provide operating personnel and required maintenance for building equipment being used by him, such as for temporary electricity, etc. After all or portions of the equipment or systems have been granted a date of substantial completion, the Contractor shall provide operating personnel and maintenance for such equipment or systems.

F. Record Drawings:

1. Provide a clean and neat set of record drawings which shall show all changes, all main control devices, all disconnecting means, all buried conduits (with dimensioned references to building lines and grades). Record drawings shall be recorded daily.
2. Record all elevations and locations prior to concealment.
3. Provide these drawings to the Engineer for his transmittal to the Owner for his use.

G. Affidavits: The Contractor(s) shall submit notarized affidavits as required by the State Fire Marshal regarding the use of approved plastic materials required to complete this work.

1.10 SUPERVISION

A. This Contractor shall have in charge of the work at all times during construction a thoroughly competent Field Superintendent with long experience in the work to be installed under this contract.

Any person not deemed capable by the Engineer shall be replaced immediately, upon the request of the Engineer, by some person who is satisfactory to the Engineer. After such person has been assigned, he shall not be withdrawn or reassigned without the consent of the Engineer.

END OF SECTION

SECTION 16050 - BASIC ELECTRICAL MATERIALS AND METHODS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:

1. Supporting devices for electrical components.
2. Concrete equipment bases.
3. Cutting and patching for electrical construction.
4. Touchup painting.

1.3 DEFINITIONS

A. EMT: Electrical metallic tubing.

B. FMC: Flexible metal conduit.

C. IMC: Intermediate metal conduit.

D. LFMC: Liquidtight flexible metal conduit.

E. RNC: Rigid nonmetallic conduit.

1.4 QUALITY ASSURANCE

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

B. Comply with NFPA 70.

1.5 COORDINATION

A. Coordinate chases, slots, inserts, sleeves, and openings with general construction work and arrange in building structure during progress of construction to facilitate the electrical installations that follow.

1. Set inserts and sleeves in poured-in-place concrete, masonry work, and other structural components as they are constructed.

B. Sequence, coordinate, and integrate installing electrical materials and equipment for efficient flow of the Work. Coordinate installing large equipment requiring positioning before closing in the building.

C. Coordinate electrical service connections to components furnished by utility companies.

1. Coordinate installation and connection of exterior underground and overhead utilities and services, including provision for electricity-metering components.
2. Comply with requirements of authorities having jurisdiction and of utility company providing electrical power and other services.

D. Coordinate location of access panels and doors for electrical items that are concealed by finished surfaces. Access doors and panels are specified in Division 8 Section "Access Doors."

PART 2 - PRODUCTS

2.1 SUPPORTING DEVICES

A. Material: Cold-formed steel, with corrosion-resistant coating acceptable to authorities having jurisdiction.

B. Metal Items for Use Outdoors or in Damp Locations: Hot-dip galvanized steel.

C. Slotted-Steel Channel Supports: Flange edges turned toward web, and 9/16-inch-diameter slotted holes at a maximum of 2 inches o.c., in webs.

D. Raceway and Cable Supports: Manufactured clevis hangers, riser clamps, straps, threaded C-clamps with retainers, ceiling trapeze hangers, wall brackets, and spring-steel clamps or click-type hangers.

E. Pipe Sleeves: ASTM A 53, Type E, Grade A, Schedule 40, galvanized steel, plain ends.

F. Cable Supports for Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug for non-armored electrical cables in riser conduits. Plugs have number and size of conductor gripping holes as required to suit individual risers. Body constructed of malleable-iron casting with hot-dip galvanized finish.

G. Expansion Anchors: Carbon-steel wedge or sleeve type.

H. Toggle Bolts: All-steel springhead type.

2.2 TOUCHUP PAINT

A. For Equipment: Equipment manufacturer's paint selected to match installed equipment finish.

B. Galvanized Surfaces: Zinc-rich paint recommended by item manufacturer.

PART 3 - EXECUTION

3.1 ELECTRICAL EQUIPMENT INSTALLATION

A. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide the maximum possible headroom.

B. Materials and Components: Install level, plumb, and parallel and perpendicular to other building systems and components, unless otherwise indicated.

C. Equipment: Install to facilitate service, maintenance, and repair or replacement of components. Connect for ease of disconnecting, with minimum interference with other installations.

D. Right of Way: Give to raceways and piping systems installed at a required slope.

3.2 ELECTRICAL SUPPORTING DEVICE APPLICATION

A. Damp Locations and Outdoors: Hot-dip galvanized materials or nonmetallic, U-channel system components.

B. Dry Locations: Steel materials.

C. Support Clamps for PVC Raceways: Click-type clamp system.

D. Selection of Supports: Comply with manufacturer's written instructions.

E. Strength of Supports: Adequate to carry present and future loads, times a safety factor of at least four; minimum of 200-lb design load.

3.3 SUPPORT INSTALLATION

A. Install support devices to securely and permanently fasten and support electrical components.

B. Install individual and multiple raceway hangers and riser clamps to support raceways. Provide U-bolts, clamps, attachments, and other hardware necessary for hanger assemblies and for securing hanger rods and conduits.

C. Support parallel runs of horizontal raceways together on trapeze- or bracket-type hangers.

D. Size supports for multiple raceway installations so capacity can be increased by a 25 percent minimum in the future.

E. Support individual horizontal raceways with separate, malleable-iron pipe hangers or clamps.

F. Install 1/4-inch-diameter or larger threaded steel hanger rods, unless otherwise indicated.

G. Spring-steel fasteners specifically designed for supporting single conduits or tubing may be used instead of malleable-iron hangers for 1-1/2-inch and smaller raceways serving lighting and receptacle branch circuits above suspended ceilings and for fastening raceways to slotted channel and angle supports.

H. Arrange supports in vertical runs so the weight of raceways and enclosed conductors is carried entirely by raceway supports, with no weight load on raceway terminals.

I. Simultaneously install vertical conductor supports with conductors.

J. Separately support cast boxes that are threaded to raceways and used for fixture support. Support sheet-metal boxes directly from the building structure or by bar hangers.

If bar hangers are used, attach bar to raceways on opposite sides of the box and support the raceway with an approved fastener not more than 24 inches from the box.

K. Install metal channel racks for mounting cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices unless components are mounted directly to structural elements of adequate strength.

L. Install sleeves for cable and raceway penetrations of concrete slabs and walls unless core-drilled holes are used. Install sleeves for cable and raceway penetrations of masonry and fire-rated gypsum walls and of all other fire-rated floor and wall assemblies. Install sleeves during erection of concrete and masonry walls.

M. Securely fasten electrical items and their supports to the building structure, unless otherwise indicated. Perform fastening according to the following unless other fastening methods are indicated:

1. Wood: Fasten with wood screws or screw-type nails.
2. Masonry: Toggle bolts on hollow masonry units and expansion bolts on solid masonry units.
3. New Concrete: Concrete inserts with machine screws and bolts.
4. Existing Concrete: Expansion bolts.
5. Steel: Welded threaded studs or spring-tension clamps on steel.

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

6. Welding to steel structure may be used only for threaded studs, not for conduits, pipe straps, or other items.
7. Light Steel: Sheet-metal screws.
8. Fasteners: Select so the load applied to each fastener does not exceed 25 percent of its proof-test load.

3.4 FIRESTOPPING

A. Apply firestopping to cable and raceway penetrations of fire-rated floor and wall assemblies to achieve fire-resistance rating of the assembly. Firestopping materials and installation requirements are specified in Division 7 Section "Firestopping."

3.5 CUTTING AND PATCHING

A. Cut, channel, chase, and drill floors, walls, partitions, ceilings, and other surfaces required to permit electrical installations. Perform cutting by skilled mechanics of trades involved.

B. Repair and refinish disturbed finish materials and other surfaces to match adjacent undisturbed surfaces. Install new fireproofing where existing firestopping has been disturbed. Repair and refinish materials and other surfaces by skilled mechanics of trades involved.

3.6 FIELD QUALITY CONTROL

A. Inspect installed components for damage and faulty work, including the following:

1. Raceways.
2. Building wire and connectors.
3. Supporting devices for electrical components.
4. Electrical identification.
5. Electricity-metering components.
6. Concrete bases.
7. Cutting and patching for electrical construction.
8. Touchup painting.

3.7 REFINISHING AND TOUCHUP PAINTING

A. Refinish and touch up paint. Paint materials and application requirements are specified in Division 9 Section "Painting."

1. Clean damaged and disturbed areas and apply primer, intermediate, and finish coats to suit the degree of damage at each location.
2. Follow paint manufacturer's written instructions for surface preparation and for timing and application of successive coats.
3. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
4. Repair damage to PVC or paint finishes with matching touchup coating recommended by manufacturer.

3.8 CLEANING AND PROTECTION

A. On completion of installation, including outlets, fittings, and devices, inspect exposed finish. Remove burrs, dirt, paint spots, and construction debris.

B. Protect equipment and installations and maintain conditions to ensure that coatings, finishes, and cabinets are without damage or deterioration at time of Substantial Completion.

END OF SECTION

SECTION 16060 - GROUNDING AND BONDING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes grounding of electrical systems and equipment. Grounding requirements specified in this Section may be supplemented by special requirements of systems described in other Sections.

1.3 QUALITY ASSURANCE

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

1. Comply with UL 467.

B. Comply with NFPA 70; for overhead-line construction and medium-voltage underground construction, comply with IEEE C2.

C. Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Grounding Conductors, Cables, Connectors, and Rods:

a. Apache Grounding/Erico Inc.
b. Boggs, Inc.
c. Chance/Hubbell.
d. Copperweld Corp.
e. Dossert Corp.
f. Erico Inc.; Electrical Products Group.
g. Galvan Industries, Inc.
h. Heary Brothers Lightning Protection Co.
i. Ideal Industries, Inc.
j. ILSCO.
k. Kearney/Cooper Power Systems.
l. Korns: C. C. Korns Co.; Division of Robroy Industries.
m. O-Z/Gedney Co.; a business of the EGS Electrical Group.

n. Raco, Inc.; Division of Hubbell.
o. Thomas & Betts, Electrical.

2.2 GROUNDING CONDUCTORS

A. For insulated conductors, comply with Division 16 Section "Conductors and Cables."

B. Material: Copper.

C. Equipment Grounding Conductors: Insulated with green-colored insulation.

D. Isolated Ground Conductors: Insulated with green-colored insulation with yellow stripe. On feeders with isolated ground, use colored tape, alternating bands of green and yellow tape to provide a minimum of three bands of green and two bands of yellow.

E. Grounding Electrode Conductors: Stranded cable.

F. Underground Conductors: Bare, tinned, solid, unless otherwise indicated.

G. Bare Copper Conductors: Comply with the following:

1. Solid Conductors: ASTM B 3.
2. Assembly of Stranded Conductors: ASTM B 8.
3. Tinned Conductors: ASTM B 33.

H. Copper Bonding Conductors: As follows:

1. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG copper conductor, 1/4 inch in diameter.
2. Bonding Conductor: No. 4 or No. 6 AWG, stranded copper conductor.
3. Bonding Jumper: Bare copper tape, braided bare copper conductors, terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.
4. Tinned Bonding Jumper: Tinned-copper tape, braided copper conductors, terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.

I. Grounding Bus: Bare, annealed copper bars of rectangular cross section, with insulators.

2.3 CONNECTOR PRODUCTS

A. Comply with IEEE 837 and UL 467; listed for use for specific types, sizes, and combinations of conductors and connected items.

B. Bolted Connectors: Bolted-pressure-type connectors, or compression type.

C. Welded Connectors: Exothermic-welded type, in kit form, and selected per manufacturer's written instructions.

2.4 GROUNDING ELECTRODES

A. Ground Rods: Copper-clad.

PART 3 - EXECUTION

3.1 APPLICATION

A. Use only copper conductors for both insulated and bare grounding conductors in direct contact with earth, concrete, masonry, crushed stone, and similar materials.

B. In raceways, use insulated equipment grounding conductors.

C. Exothermic-Welded Connections: Use for connections to structural steel and for underground connections, except those at test wells.

D. Equipment Grounding Conductor Terminations: Use bolted pressure clamps.

E. Grounding Bus: Install in electrical and telephone equipment rooms, in rooms housing service equipment, and elsewhere as indicated.

1. Use insulated spacer; space 1 inch from wall and support from wall 6 inches above finished floor, unless otherwise indicated.

F. Underground Grounding Conductors: Use tinned-copper conductor, No. 2 AWG minimum. Bury at least 24 inches below grade or bury 12 inches above duct bank when installed as part of the duct bank.

3.2 EQUIPMENT GROUNDING CONDUCTORS

A. Comply with NFPA 70, Article 250, for types, sizes, and quantities of equipment grounding conductors, unless specific types, larger sizes, or more conductors than required by NFPA 70 are indicated.

B. Install equipment grounding conductors in all feeders and circuits.

C. Install insulated equipment grounding conductor with circuit conductors for the following items, in addition to those required by NEC:

1. Feeders and branch circuits.
2. Lighting circuits.
3. Receptacle circuits.
4. Single-phase motor and appliance branch circuits.
5. Three-phase motor and appliance branch circuits.
6. Flexible raceway runs.
7. Armored and metal-clad cable runs.

D. Computer Outlet Circuits: Install insulated equipment grounding conductor in branch-circuit runs from computer-area power panels or power-distribution units.

E. Isolated Grounding Receptacle Circuits: Install an insulated equipment grounding conductor connected to the receptacle grounding terminal. Isolate grounding conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service, unless otherwise indicated.

F. Isolated Equipment Enclosure Circuits: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply raceway with a nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure and install a separate equipment grounding conductor. Isolate equipment grounding conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service, unless otherwise indicated.

G. Nonmetallic Raceways: Install an equipment grounding conductor in nonmetallic raceways unless they are designated for telephone or data cables.

H. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate equipment grounding conductor to each electric water heater, heat-tracing, and antifrost heating cable. Bond conductor to heater units, piping, connected equipment, and components.

I. Signal and Communication Systems: For telephone, alarm, voice and data, and other communication systems, provide No. 4 AWG minimum insulated grounding conductor in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location.

1. Service and Central Equipment Locations and Wiring Closets: Terminate grounding conductor on a 1/4-by-2-by-12-inch grounding bus.
2. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.

J. Metal Poles Supporting Outdoor Lighting Fixtures: Provide a grounding electrode in addition to installing a separate equipment grounding conductor with supply branch-circuit conductors.

3.3 INSTALLATION

A. Ground Rods: Install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes.

1. Drive ground rods until tops are 2 inches below finished floor or final grade, unless otherwise indicated.
2. Interconnect ground rods with grounding electrode conductors. Use exothermic welds, except at test wells and as otherwise indicated. Make connections without exposing steel or damaging copper coating.

B. Grounding Conductors: Route along shortest and straightest paths possible, unless otherwise indicated. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

C. Bonding Straps and Jumpers: Install so vibration by equipment mounted on vibration isolation hangers and supports is not transmitted to rigidly mounted equipment. Use exothermic-welded connectors for outdoor locations, unless a disconnect-type connection is required; then, use a bolted clamp. Bond straps directly to the basic structure taking care not to penetrate any adjacent parts. Install straps only in locations accessible for maintenance.

D. Metal Water Service Pipe: Provide insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes by grounding clamp connectors.

Where a dielectric main water fitting is installed, connect grounding conductor to street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.

E. Water Meter Piping: Use bonding jumpers to electrically bypass water meters. Connect to pipe with grounding clamp connectors.

F. Bond interior metal piping systems and metal air ducts to equipment grounding conductors of associated pumps, fans, blowers, electric heaters, and air cleaners. Use braided-type bonding straps.

G. Bond each aboveground portion of gas piping system upstream from equipment shutoff valve.

3.4 CONNECTIONS

A. General: Make connections so galvanic action or electrolysis possibility is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact will be galvanically compatible.

1. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer to order of galvanic series.
2. Make connections with clean, bare metal at points of contact.
3. Make aluminum-to-steel connections with stainless-steel separators and mechanical clamps.
4. Make aluminum-to-galvanized steel connections with tin-plated copper jumpers and mechanical clamps.
5. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.

B. Exothermic-Welded Connections: Comply with manufacturer's written instructions. Welds that are puffed up or that show convex surfaces indicating improper cleaning are not acceptable.

C. Equipment Grounding Conductor Terminations: For No. 8 AWG and larger, use pressure-type grounding lugs. No. 10 AWG and smaller grounding conductors may be terminated with winged pressure-type connectors.

D. Non-contact Metal Raceway Terminations: If metallic raceways terminate at metal housings without mechanical and electrical connection to housing, terminate each conduit with a grounding bushing. Connect grounding bushings with a bare grounding conductor to grounding bus or terminal in housing. Bond electrically non-continuous conduits at entrances and exits with grounding bushings and bare grounding conductors, unless otherwise indicated.

E. Tighten screws and bolts for grounding and bonding connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A.

F. Compression-Type Connections: Use hydraulic compression tools to provide correct circumferential pressure for compression connectors. Use tools and dies recommended by connector manufacturer. Provide embossing die code or other standard method to make a visible indication that a connector has been adequately compressed on grounding conductor.

G. Moisture Protection: If insulated grounding conductors are connected to ground rods or grounding buses, insulate entire area of connection and seal against moisture penetration of insulation and cable.

3.5 FIELD QUALITY CONTROL

A. Testing: Perform the following field quality-control testing:

1. After installing grounding system but before permanent electrical circuitry has been energized, test for compliance with requirements.
2. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, and at ground test wells. Measure ground resistance not less than two full days after the last trace of precipitation, and without the soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance. Perform tests, by the fall-of-potential method according to IEEE 81.
3. Provide drawings locating each ground rod and ground rod assembly and other grounding electrodes, identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.

    a. Equipment Rated 500 kVA and Less: 10 ohms.
    b. Equipment Rated 500 to 1000 kVA: 5 ohms.
    c. Equipment Rated More Than 1000 kVA: 3 ohms.
    d. Substations and Pad-Mounted Switching Equipment: 5 ohms.
    e. Manhole Grounds: 10 ohms.

4. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

3.6 GRADING AND PLANTING

A. Restore surface features, including vegetation, at areas disturbed by Work of this Section. Reestablish original grades, unless otherwise indicated. If sod has been removed, replace it as soon as possible after backfilling is completed. Restore areas disturbed by trenching, storing of dirt, cable laying, and other activities to their original condition. Include application of topsoil, fertilizer, lime, seed, sod, sprig, and mulch. Comply with Division 2 Section "Landscaping." Maintain restored surfaces. Restore disturbed paving as indicated.

END OF SECTION

SECTION 16075 - ELECTRICAL IDENTIFICATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes electrical identification materials and devices required to comply with ANSI C2, NFPA 70, OSHA standards, and authorities having jurisdiction.

1.3 QUALITY ASSURANCE

A. Comply with ANSI C2.

B. Comply with NFPA 70.

C. Comply with ANSI A13.1 and NFPA 70 for color-coding.

PART 2 - PRODUCTS

2.1 RACEWAY AND CABLE LABELS

A. Comply with ANSI A13.1, Table 3, for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.

1. Color: Black letters on orange field.
2. Legend: Indicates voltage.

B. Pre-tensioned, Wraparound Plastic Sleeves: Flexible, preprinted, color-coded, acrylic band sized to suit the diameter of the line it identifies and arranged to stay in place by pre-tensioned gripping action when placed in position.

C. Colored Adhesive Tape: Self-adhesive vinyl tape not less than 3 mils thick by 1 to 2 inches wide.

D. Underground-Line Warning Tape: Permanent, bright-colored, continuous-printed, vinyl tape.

1. Not less than 6 inches wide by 4 mils thick.
2. Compounded for permanent direct-burial service.
3. Embedded continuous metallic strip or core.
4. Printed legend indicating type of underground line.

E. Tape Markers: Vinyl or vinyl-cloth, self-adhesive, wraparound type with preprinted numbers and letters.

F. Plasticized Card-Stock Tags: Vinyl cloth with preprinted and field-printed legends. Orange background, unless otherwise indicated, with eyelet for fastener.

G. Brass or Aluminum Tags: 2 by 2 by 0.05-inch metal tags with stamped legend, punched for fastener.

2.2 NAMEPLATES AND SIGNS

A. Safety Signs: Comply with 29 CFR, Chapter XVII, Part 1910.145.

B. Engraved Plastic Nameplates and Signs: Engraving stock, melamine plastic laminate, minimum 1/16 inch thick for signs up to 20 sq. in. and 1/8 inch thick for larger sizes.

1. Engraved legend with black letters on white face.
2. Punched or drilled for mechanical fasteners.

C. Baked-Enamel Signs for Interior Use: Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for the application. 1/4-inch grommets in corners for mounting.

D. Exterior, Metal-Backed, Butyrate Signs: Weather-resistant, non-fading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch galvanized-steel backing; and with colors, legend, and size required for the application. 1/4-inch grommets in corners for mounting.

E. Fasteners for Nameplates and Signs: Self-tapping, stainless-steel screws or No. 10/32, stainless-steel machine screws with nuts and flat and lock washers.

2.3 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Cable Ties: Fungus-inert, self-extinguishing, one-piece, self-locking, Type 6/6 nylon cable ties.

1. Minimum Width: 3/16 inch.
2. Tensile Strength: 50 lb minimum.
3. Temperature Range: Minus 40 to plus 185 deg F.
4. Color: According to color-coding.

B. Paint: Formulated for the type of surface and intended use.

1. Primer for Galvanized Metal: Single-component acrylic vehicle formulated for galvanized surfaces.
2. Primer for Concrete Masonry Units: Heavy-duty-resin block filler.
3. Primer for Concrete: Clear, alkali-resistant, binder-type sealer.
4. Enamel: Silicone-alkyd or alkyd urethane as recommended by primer manufacturer.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Identification Materials and Devices: Install at locations for most convenient viewing without interference with operation and maintenance of equipment.

B. Lettering, Colors, and Graphics: Coordinate names, abbreviations, colors, and other designations with corresponding designations in the Contract Documents or with those required by codes and standards. Use consistent designations throughout Project.

C. Sequence of Work: If identification is applied to surfaces that require finish, install identification after completing finish work.

D. Self-Adhesive Identification Products: Clean surfaces before applying.

E. Install painted identification according to manufacturer's written instructions and as follows:

1. Clean surfaces of dust, loose material, and oily films before painting.
2. Prime surfaces using type of primer specified for surface.
3. Apply one intermediate and one finish coat of enamel.

F. Color Banding Raceways and Exposed Cables: Band exposed and accessible raceways of the systems listed below:

1. Bands: Pre-tensioned, wraparound plastic sleeves; colored adhesive tape; or a combination of both. Make each color band 2 inches wide, completely encircling conduit, and place adjacent bands of two-color markings in contact, side by side.
2. Band Locations: At changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.
3. Apply the following colors to the systems listed below:

    a. Fire Alarm System: Red.
    b. Telecommunication System: Green and yellow.

G. Caution Labels for Indoor Boxes and Enclosures for Power and Lighting: Install pressure-sensitive, self-adhesive labels identifying system voltage with black letters on orange background. Install on exterior of door or cover.

H. Circuit Identification Labels on Boxes: Install labels externally.

1. Exposed Boxes: Pressure-sensitive, self-adhesive plastic label on cover.
2. Concealed Boxes: Plasticized card-stock tags.
3. Labeling Legend: Permanent, waterproof listing of panel and circuit number or equivalent.

I. Paths of Underground Electrical Lines: During trench backfilling, for exterior underground power, control, signal, and communication lines, install continuous underground plastic line marker located directly above line at 6 to 8 inches below finished grade. Where width of multiple lines installed in a common trench or concrete envelope does not exceed 16 inches overall, use a single line marker. Install line marker for underground wiring, both direct-buried cables and cables in raceway.

J. Secondary Service, Feeder, and Branch-Circuit Conductors: Color-code throughout the secondary electrical system.

1. Color-code 208/120-V system as follows:

   a. Phase A: Black.
   b. Phase B: Red.
   c. Phase C: Blue.
   d. Neutral: White.
   e. Ground: Green.

2. Color-code 480/277V system as follows:

   a. Phase A: Yellow
   b. Phase B: Brown
   c. Phase C: Orange
   d. Neutral: White with a colored stripe of gray.
   e. Ground: Green

3. Factory apply color the entire length of conductors, except the following field-applied, color-coding methods may be used instead of factory-coded wire for sizes larger than No. 10 AWG:

   a. Colored, pressure-sensitive plastic tape in half-lapped turns for a distance of 6 inches from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Use 1-inch-wide tape in colors specified. Adjust tape bands to avoid obscuring cable identification markings.
   b. Colored cable ties applied in groups of three ties of specified color to each wire at each terminal or splice point starting 3 inches from the terminal and spaced 3 inches apart. Apply with a special tool or pliers, tighten to a snug fit, and cut off excess length.

K. Power-Circuit Identification: Metal tags or aluminum, wraparound marker bands for cables, feeders, and power circuits in vaults, pull and junction boxes, manholes, and switchboard rooms.

1. Legend: 1/4-inch-steel letter and number stamping or embossing with legend corresponding to indicated circuit designations.
2. Tag Fasteners: Nylon cable ties.
3. Band Fasteners: Integral ears.

L. Apply identification to conductors as follows:

1. Conductors to be Extended in the Future: Indicate source and circuit numbers.
2. Multiple Power or Lighting Circuits in the Same Enclosure: Identify each conductor with source, voltage, circuit number, and phase. Use color-coding to identify circuits' voltage and phase.
3. Multiple Control and Communication Circuits in the Same Enclosure: Identify each conductor by its system and circuit designation. Use a consistent system of tags, color-coding, or cable marking tape.

M. Apply warning, caution, and instruction signs as follows:

1. Warnings, Cautions, and Instructions: Install to ensure safe operation and maintenance of electrical systems and of items to which they connect.

   Install engraved plastic-laminated instruction signs with approved legend where instructions are needed for system or equipment operation. Install metal-backed butyrate signs for outdoor items.

2. Emergency Operation: Install engraved laminated signs with white legend on red background with minimum 3/8-inch-high lettering for emergency instructions on power transfer, load shedding, and other emergency operations.

N. Equipment Identification Labels: Engraved plastic laminate. Install on each unit of equipment, including central or master unit of each system. This includes power, lighting, communication, signal, and alarm systems, unless units are specified with their own self-explanatory identification. Unless otherwise indicated, provide a single line of text with 1/2-inch-high lettering on 1-1/2-inch-high label; where two lines of text are required, use labels 2 inches high. Use white lettering on black field. Apply labels for each unit of the following categories of equipment using mechanical fasteners:

1. Panelboards, electrical cabinets, and enclosures.
2. Access doors and panels for concealed electrical items.
3. Electrical switchgear and switchboards.
4. Emergency system boxes and enclosures.
5. Disconnect switches.
6. Enclosed circuit breakers.
7. Motor starters.
8. Push-button stations.
9. Power transfer equipment.
10. Contactors.
11. Control devices.
12. Telephone switching equipment.
13. Call system master station.
14. TV/audio-monitoring master station.
15. Fire alarm master station or control panel.

END OF SECTION

SECTION 16120 - CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes building wires and cables and associated connectors, splices, and terminations for wiring systems rated 600 V and less.

1.3 DELIVERY, STORAGE, AND HANDLING

A. Deliver wires and cables according to NEMA WC 26.

1.4 COORDINATION

A. Coordinate layout and installation of cables with other installations.

B. Revise locations and elevations from those indicated, as required to suit field conditions and as approved by Engineer.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Wires and Cables:

    a. American Insulated Wire Corporation
    b. BICC Brand-Rex Company
    c. Carol Cable Company, Inc.
    d. Senator Wire & Cable Company
    e. Southwire Company.

2. Connectors for Wires and Cables:

    a. AMP Inc.
    b. General Signal
    c. Monogram Company
    d. Square D Company
    e. 3M Company

2.2 BUILDING WIRES AND CABLES

A. UL-listed building wires and cables with conductor material, insulation type, cable construction, and rating as specified in Part 3 "Wire and Insulation Applications" Article.

B. Thermoplastic Insulation Material: Comply with NEMA WC 5.

C. Conductor Material: Copper.

D. Stranding: Solid conductor for No. 14 AWG and smaller; stranded conductor for larger than No. 14 AWG.

2.3 CONNECTORS AND SPLICES

A. UL-listed, factory-fabricated wiring connectors of size, ampacity rating, material, type, and class for application and service indicated. Comply with Project's installation requirements and as specified in Part 3 "Wire and Insulation Applications" Article.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine raceways and building finishes to receive wires and cables for compliance with requirements for installation tolerances and other conditions affecting performance of wires and cables. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 WIRE AND INSULATION APPLICATIONS

A. Feeders: Type THHN/THWN, in raceway.

B. Branch Circuits: Type THHN/THWN, in raceway.

C. Class 1 Control Circuits: Type THHN/THWN, in raceway.

D. Class 2 Control Circuits: Type THHN/THWN, in raceway.

3.3 INSTALLATION

A. Install wires and cables as indicated, according to manufacturer's written instructions and NECA's "Standard of Installation."

B. Pull Conductors: Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

C. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips that will not damage cables or raceway.

D. Support cables according to Division 16 Section "Basic Electrical Materials and Methods."

E. Seal around cables penetrating fire-rated elements according to Division 7 Section "Firestopping."

F. Identify wires and cables according to Division 16 Section "Electrical Identification”.

3.4 CONNECTIONS

A. Conductor Splices: Keep to minimum.

B. Install splices and tapes that possess equivalent or better mechanical strength and insulation ratings than conductors being spliced.

C. Use splice and tap connectors compatible with conductor material.

D. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

END OF SECTION

SECTION 16130 - RACEWAYS AND BOXES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes raceways, fittings, boxes, enclosures, and cabinets for electrical wiring.

1. Raceways include the following:

a. RMC.
b. IMC.
c. EMT.
d. FMC.
e. LFMC.
f. RNC.
g. Wireways.

2. Boxes, enclosures, and cabinets include the following:

a. Device boxes.
b. Floor boxes.
c. Outlet boxes.
d. Pull and junction boxes.
e. Cabinets and hinged-cover enclosures.

B. Related Sections include the following:

1. Division 7 Section "Firestopping."
2. Division 16 Section "Basic Electrical Materials and Methods" for raceways and box supports.

1.3 DEFINITIONS

A. RMC: Rigid Metallic Conduit.

B. EMT: Electrical metallic tubing.

C. FMC: Flexible metal conduit.

D. IMC: Intermediate metal conduit.

E. LFMC: Liquidtight flexible metal conduit.

F. RNC: Rigid nonmetallic conduit.

1.4 QUALITY ASSURANCE

A. Listing and Labeling: Provide raceways and boxes specified in this Section that are listed and labeled.

1. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" as defined in OSHA Regulation 1910.7.

B. Comply with NECA's "Standard of Installation."

C. Comply with NFPA 70.

1.5 COORDINATION

A. Coordinate layout and installation of raceways and boxes with other construction elements to ensure adequate headroom, working clearance, and access.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Metal Conduit and Tubing:

a. Alflex Corporation
b. Anamet, Inc.
c. Carol Cable Company, Inc.
d. Cole-Flex Corporation
e. Electri-Flex Company
f. Flexcon, Inc.
g. Grinnell Company
h. Monogram Company
i. Triangle PWC, Inc.
j. Wheatland Tube Company

2. Nonmetallic Conduit and Tubing:

a. Anamet, Inc.
b. Arnco Corporation
c. Cantex Industries
d. Certainteed Corporation
e. Cole-Flex Corporation
f. Electri-Flex Company
g. Hubbell, Inc.
h. R&G Sloan Manufacturing Company, Inc.
i. Thomas & Betts Corporation

3. Conduit Bodies and Fittings:

    a. American Electric
    b. Crouse-Hinds
    c. Hubbell, Inc.
    d. O-Z/Gedney
    e. Spring City Electrical Manufacturing Company

4. Metal Wireways:

    a. Hoffman Engineering Company
    b. Keystone/Rees, Inc.
    c. Square D Company

5. Surface Metal Raceways:

    a. Wiremold Company

6. Boxes, Enclosures, and Cabinets:

    a. Butler Manufacturing Company
    b. Crouse-Hinds
    c. Hoffman Engineering Company
    d. Hubbell, Inc.
    e. O-Z/Gedney
    f. Parker Electrical Manufacturing Company
    g. Robroy Industries, Inc.
    h. Spring City Electrical Manufacturing Company
    i. Thomas & Betts Corporation
    j. Woodhead Industries, Inc.

2.2 METAL CONDUIT AND TUBING

A. Rigid Steel Conduit: ANSI C80.1.

B. IMC: ANSI C80.6.

C. EMT and Fittings: ANSI C80.3.

1. Fittings: Compression.

D. FMC: Zinc-coated steel. Note:FMC for use as fixture "whips" in patient care area or treatment areas shall have integral redundant ground return path. **NOTE: Standard FMC does not have this feature. See NEC 517-13-(b).**

E. LFMC: Flexible steel conduit with PVC jacket.

F. Fittings: NEMA FB 1; compatible with conduit/tubing materials.

2.3 NONMETALLIC CONDUIT AND TUBING

A. RNC: NEMA TC 2, Schedule 40 or 80 PVC.

B. RNC Fittings: NEMA TC 3; match to conduit or conduit/tubing type and material.

2.4 METAL WIREWAYS

A. Material: Sheet metal sized and shaped as indicated.

B. Fittings and Accessories: Include 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.

C. Select features, unless otherwise indicated, as required to complete wiring system and to comply with NFPA 70.

D. Wireway Covers: Hinged type.

E. Finish: Manufacturer's standard enamel finish.

2.5 SURFACE RACEWAYS

A. Surface Metal Raceways: Galvanized steel with snap-on covers. Finish with manufacturer's standard prime coating.

B. Types, sizes, and channels as indicated and required for each application, with fittings that match and mate with raceways.

2.6 PULL AND JUNCTION BOXES

A. Small Sheet Metal Boxes: NEMA OS 1.

B. Cast-Metal Boxes: NEMA FB 1, cast aluminum or iron with gasketed cover.

2.7 ENCLOSURES AND CABINETS

A. Hinged-Cover Enclosures: NEMA 250, Type 1, with continuous hinge cover and flush latch.

1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.

B. Cabinets: NEMA 250, Type 1, galvanized steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel. Hinged door in front cover with flush latch and concealed hinge. Key latch to match panelboards. Include metal barriers to separate wiring of different systems and voltage, and include accessory feet where required for freestanding equipment.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine surfaces to receive raceways, boxes, enclosures, and cabinets for compliance with installation tolerances and other conditions affecting performance of raceway installation. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 WIRING METHODS

A. Outdoors: Use the following wiring methods:

1. Exposed: Rigid steel or IMC.
2. Concealed: Rigid steel or IMC.
3. Underground, Single Run: RNC.
4. Underground, Grouped: RNC.
5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
6. Boxes and Enclosures: NEMA 250, Type 3R or Type 4.

B. Indoors: Use the following wiring methods:

1. Exposed: EMT. (Use IMC for feeders and as noted.)
2. Concealed: EMT. (Use IMC for feeders and as noted.)
3. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC; except in wet or damp locations, use LFMC.
4. Damp or Wet Locations: Rigid steel conduit.
5. Boxes and Enclosures: NEMA 250, Type 1, except as follows:

    a. Damp or Wet Locations: NEMA 250, Type 4, nonmetallic.

3.3 INSTALLATION

A. Install raceways, boxes, enclosures, and cabinets as indicated, according to manufacturer's written instructions.

B. Minimum Raceway Size: 3/4-inch trade size.

C. Conceal conduit and EMT, unless otherwise indicated, within finished walls, ceilings, and floors.

D. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.

E. Install raceways level and square and at proper elevations. Provide adequate headroom.

F. Complete raceway installation before starting conductor installation.

G. Support raceways as specified in Division 16 Section "Basic Electrical Materials and Methods."

H. Use temporary closures to prevent foreign matter from entering raceways.

I. Protect stub-ups from damage where conduits rise through floor slabs. Arrange so curved portion of bends is not visible above the finished slab.

J. Make bends and offsets so ID is not reduced. Keep legs of bends in the same plane and straight legs of offsets parallel, unless otherwise indicated.

K. Use raceway fittings compatible with raceways and suitable for use and location. For intermediate steel conduit, use threaded rigid steel conduit fittings, unless otherwise indicated.

L. Run concealed raceways, with a minimum of bends, in the shortest practical distance considering the type of building construction and obstructions, unless otherwise indicated.

M. Raceways Embedded in Slabs: Install in middle third of slab thickness where practical and leave at least 1-inch concrete cover.

1. Secure raceways to reinforcing rods to prevent sagging or shifting during concrete placement.
2. Space raceways laterally to prevent voids in concrete.
3. Run conduit larger than 1-inch trade size parallel to or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support.
4. Transition from nonmetallic tubing to Schedule 80 nonmetallic conduit, rigid steel conduit, or IMC before rising above floor.

N. Install exposed raceways parallel to or at right angles to nearby surfaces or structural members and follow the surface contours as much as practical.

1. Run parallel or banked raceways together, on common supports where practical.
2. Make bends in parallel or banked runs from same centerline to make bends parallel. Use factory elbows only where elbows can be installed parallel; otherwise, provide field bends for parallel raceways.

O. Join raceways with fittings designed and approved for the purpose and make joints tight.

1. Make raceway terminations tight. Use bonding bushings or wedges at connections subject to vibration. Use bonding jumpers where joints cannot be made tight.
2. Use insulating bushings to protect conductors.

P. Terminations: Where raceways are terminated with locknuts and bushings, align raceways to enter squarely and install locknuts with dished part against the box. Where terminations are not secure with 1 locknut, use 2 locknuts: 1 inside and 1 outside the box.

Q. Where raceways are terminated with threaded hubs, screw raceways or fittings tightly into the hub so the end bears against the wire protection shoulder. Where chase nipples are used, align raceways so the coupling is square to the box and tighten the chase nipple so no threads are exposed.

R. Install pull wires in empty raceways. Use No. 14 AWG zinc-coated steel or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of the pull wire.

S. Telephone and Signal System Raceways, 2-Inch Trade Size and Smaller: In addition to the above requirements, install raceways in maximum lengths of 150 feet and with a maximum of two 90-degree bends or equivalent. Separate lengths with pull or junction boxes where necessary to comply with these requirements.

T. Stub-up Connections: Extend conduits through concrete floor for connection to freestanding equipment. Install with an adjustable top or coupling threaded inside for plugs set flush with the finished floor. Extend conductors to equipment with rigid steel conduit; FMC may be used 6 inches above the floor. Install screwdriver-operated, threaded flush plugs flush with floor for future equipment connections.

U. Flexible Connections: Use maximum of 6 feet of flexible conduit for recessed and semirecessed lighting fixtures; for equipment subject to vibration, noise transmission, or movement; and for all motors. Use liquidtight flexible conduit in wet or damp locations. Install separate ground conductor across flexible connections.

V. Install hinged-cover enclosures and cabinets plumb. Support at each corner.

3.4 PROTECTION

A. Provide final protection and maintain conditions, in a manner acceptable to manufacturer and Installer that ensure coatings, finishes, and cabinets are without damage or deterioration at the time of Substantial Completion.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
2. Repair damage to PVC or paint finishes with matching touchup coating recommended by manufacturer.

3.5 CLEANING

A. On completion of installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finish, including chips, scratches, and abrasions.

END OF SECTION